# YARN AND CLOTH MAKING

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# Yarn and Cloth Making

## An Economic Study

*A College and Normal School Text Preliminary to Fabric Study*

AND

*A Reference for Teachers of Industrial History and Art in Secondary and Elementary Schools*

BY

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# PREFACE

The great waste by the clothing consumer due to ignorance of fabric values has called forth this college and normal school text-book on "Yarn and Cloth Making." Its object is to awaken in the student a deeper appreciation for economic values. In following the evolving science of spinning and weaving one gains a new valuation, as well as a distaste for waste.

The unique arrangement of subject matter makes it helpful also to teachers in secondary and elementary schools searching for material suited to their particular problems. Hitherto no one has presented in a consecutive study the simplest methods of yarn and cloth making by peoples of lower culture. These are richly suggestive to the instructor of younger children.

Teachers of industrial history and economics interested in tracing industrial growth and the "dynamic forces which mold society" will find the topics "Outline" and "Economic Gain" in convenient form for studying the textile industry, which plays a rôle in social history second only to agriculture.

A concise and systematic treatment of the subject will be valued by students of the industrial arts working out problems that need definite data as to implements,

processes and working principles related to the means and methods of manufacture.

The rural school with limited appropriation, as well as the expanding city school, needing help in a wise selection of library books and stereopticon slides, will find the carefully rated bibliographies and reference lists of illustrations of indispensable service.

Fresh knowledge of scientific facts concerning yarn and cloth making is being gathered by the general anthropologist, who needs the guide of a specialist to direct in this highly specialized field of textiles as to just what technical data are of moment and most important to look for on the expedition. To him "Distinctive Characteristics" and "Outline" will prove of assistance not only in his investigation and research, but in suggesting correct terminology to phrase his reports of the facts which he has gleaned.

To the industrial museum official, the technical librarian and the textile mechanic the "Outline" topics should make "Yarn and Cloth Making" invaluable for desk reference. It includes in a nutshell a great wealth of related textile facts and data usable in the laboratory, library and museum for selecting and analyzing material and for its labeling.

Acknowledgment is due to Anna la Tomette Blauvelt, who compiled the list of Books for Juveniles and assisted in the compilation of the list of magazine illustrations. Credit is given for each illustration in the List of Illustrations.

# INTRODUCTION

At a moment when our country's thought is centered on conservation of resources, on economic preservation of health and human energy and on the development of the younger generation for the highest service to mankind, it is an apt season to consider lack in economy and useless dissipation along clothing lines. Social economists are stating that here is one of our greatest present-day wastes. To eliminate this loss and lessen wastefulness, the purchaser needs discrimination in his choice of clothing both as to the style or cut of garment and as to the quality of the textile fabric. It is the object of this text to deal with fabrics. Through arousing an interest in spending more wisely and with fuller return, whether in the purchase of cloth by the yard or in the ready-to-wear garment, this work aims to make a more discriminating consumer of the fabric.

Textile study in colleges and normal schools to-day has a tendency to swing to exclusive fabric study and away from textile manufacture. This is the result of a previous too extensive consideration of manufacture and one unrelated to its economic bearing upon the product. Exclusive study of the fabric leads the student to think of the fabric in its "already-made" form and not in relation to the energies which bring it into being

and the economic accomplishment of these energies. There is a general failure to recognize the underlying sciences, forgetting that fabrics owe their existence to the mechanical and chemical sciences. Previous to college fabric study some knowledge of these seems imperative. One cannot intelligently approach fabric problems involving chemical science without a general knowledge of chemistry. Neither can one successfully approach fabric problems without a little understanding of the dynamic power of mechanical science underlying fabric making.

The few facts of textile mechanics presented in "Yarn and Cloth Making" have been assembled to supply a need for some knowledge of mechanical science preliminary to fabric study. In brief form, the course carries spinning and weaving from their crude beginnings into the machine processes. It is an intensive study of a narrow but fundamental field, with a focus upon the economic gain achieved as spindle and loom became more efficient in producing improved yarn and cloth. The plan was tested out at one of our universities and the results of the experiment far exceeded expectation. For, as the student followed the expanding science step by step and traced the definite gain in each progressive type, he gained two important things: a clear knowledge of good yarn and cloth, together with a rich appreciation of economic values.

Nothing is more needed to-day to stem the tide of extravagant and wasteful expenditure in clothing than such an appreciation of fabrics. Art appreciation courses

are found in many of our schools, not to educate artists, but to give future consumers the ability to surround themselves with good art. Educators know it is useless to teach what is good and what is poor art, unless with it is instilled a love for the beautiful. It is just as fruitless to attempt a reform in clothing waste, without instilling a taste and desire for what is of economic worth.

A great deficiency in our education to-day is that household science is not approached in a more investigatory manner. For in the atmosphere of inquiry and research is teaching most effective. When viewed from this angle the study of practical subjects furnishes a liberal education. Convinced of this the author hopes that "Yarn and Cloth Making" may be of wide use. Its suggestive and flexible arrangement adapts it to schools of all grades where the subject is taught, and to localities where instruction is given under widely differing conditions.

## METHODS OF USING TEXT-BOOK

*a*. As a college or normal school text "Yarn and Cloth Making" is preferably supplemented by outside reading as suggested in the section "Bibliographies." The subject matter is grouped in two sections under "Yarn Making" and "Cloth Making," each of which is considered in an opening descriptive text, followed by a series of Type Studies of the distinct varieties of spinning and weaving. Each of these types is presented under three heads: Distinctive Characteristics, a short clear statement of the salient points of the type; Outline, a plan giving details as to implement, power and process; and Economic Gain, as to quality and quantity. Cross references are found after the various topics of the outline, calling attention to explanatory material, with corresponding numbering in the descriptive text under Yarn Making and Cloth Making. Accompanying each type is a specific Bibliography carefully graded as to fullness of text for this type. These bibliographies afford student, and teacher with limited time, rapid reference to the best books. Lists of Illustrations are supplied each section for clarifying the text and for slide making, and following the General Bibliography is the Magazine Illustration and a list of elementary books in which pictures may be found.

*b.* When time is limited, the course may be shortened and yet the constructive sequence be maintained by combining into thirteen lessons as follows:

(1) Sp. I, II, III, IV. Hand spinning.
(2) Sp. V, VI. Wheel spinning.
(3) Sp. VII. Spinning jenny.
(4) Sp. VIII. Water frame.
(5) Sp. IX, X. Mule spinning.
(6) Sp. XI. Power spinning frame.
(7) W. I, II. Suspended warp looms.
(8) W. III, IV. Two-bar looms.
(9) W. V. Two-beam looms.
(10) W. VI, VII, VIII. Shaft looms.
(11) W. IX. Perfected hand loom.
(12) W. X, XI. Pattern looms.
(13) W. XII. Power looms.

*c.* Another means of shortening for classes with limited time is a selective one, using only culminating types. In this case the topic "Economic Gain" should be omitted, the deductions as to gain being drawn from the "Outline."

(1) Sp. IV. Hand spindle.
(2) Sp. VI. Flax wheel.
(3) Sp. IX. Hand mule.
(4) Sp. XI. Power spinning frame.
(5) W. V. Two-beam looms.
(6) W. IX. Perfected hand loom.
(7) W. XI. Jacquard hand loom.
(8) W. XII. Power loom.

*d.* A narrower selection gives the fundamental principles of spinning and weaving in four lessons, considering "Distinctive Characteristics" and "Outline" only.

(1) Sp. IV. Hand spindle.
(2) Sp. VI. Spinning wheel.
(3) W. V. Stretched warp loom.
(4) W. IX. Perfected hand loom.

*e.* Elementary schools can use simple selections from the "Outline" of

(1) Spinning III. Navajo Indian spinning.

(2) Weaving V. Navajo Indian weaving.

*f.* Secondary schools will find helpful:

(1) Sp. V, VI. Colonial spinning.

(2) Sp. X, XI. Power spinning (simply).

(3) W. IX. Colonial weaving.

(4) W. XI. Power weaving (very simply).

*g.* Elementary industrial arts will find suggestive for construction work:

Sp. III, IV, V, VI and Weaving I, II, III, IV, V, VI.

*h.* As few as three reference books may be used with this study, although more makes a far richer course. Most libraries have in the general stacks three exceedingly helpful books: Encyclopædia Britannica, New International Cyclopedia and National Museum Report of 1914. With these the best books follow:

3. Barlow, "History of weaving"; Marsden, "Cotton spinning"; Kissell, "Fabrics from primitive looms." (In prep.)
5. Marsden, "Cotton weaving"; Hooper, "Hand-loom weaving."
7. Ure, "Cotton manufacture"; Baines, "Cotton manufacture."
9. Foreman, "Stories of useful inventions"; Woolman and McGowan, "Textiles."
13. Murphy, "The textile industries," II, III, IV, V.
15. James, "Worsted manufacture"; Wilkinson, "Story of the cotton plant."

17. Earl, "Home life in colonial days"; Blount, "Story of home-spun web."
19. Beaumont, "Wool manufacture"; Mason, "Origin of inventions."

NOTE. — The Outlines digress from the usual numeral and letter classifications. Here the capital and small letters are reserved for different varieties under the type and the numerals for processes common to all varieties.

Titles are omitted from the Illustration lists; they are given in full, however, in the Bibliographies. The bracketed numerals are inserted for their identification.

# SUGGESTIVE PLAN FOR STUDY

## I. HAND SPINNING

1. Select from the library one or two books from the specific "Bibliography" under Spinning I.
2. Read "Yarn Making" right-hand reference numbers 1 to 7 for general introduction to spinning.
3. Read "Distinctive Characteristics" to get general survey of Hand Spinning.
4. Under Outline follow the various topics, and read from selected books on these topics to enlarge grasp of subject.
5. Where cross reference numbers appear in the Outline, look up corresponding right-hand numbers under "Yarn Making."
6. Read "Economic Gain" and enlarge upon that given.

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# LIST OF ILLUSTRATIONS

## AND THEIR SOURCE

# YARN AND CLOTH MAKING

## YARN MAKING

1 The story of fabric making through its long and varied development is a fascinating tale which reads like a fairy legend inspired by some magic genii. Even in earliest times man has had a desire to conquer the forces of nature, to harness and control them for his good. In primitive man this desire was so strong that he appealed to the spirit world for aid: to the spirits of earth and sky, to the supernatural power in plants and animals. Likewise ancient and medieval man sought the help of " good fairies, and good-natured giants, wishing caps, seven league boots, magic rings, invisible cloaks and magic wands." No doubt the belief in these supernatural powers was an inspiration to man as he pushed forward to conquer, but the real impulse which stimulated the existence and growth of industry, including the textile arts, was grim necessity. The magic force which made possible its achievement was man's inventive faculty responding to economic pressure. Fabric making did not advance along the highroad of easy success. With many hindrances and failures, by much experiment-

ing and testing it struggled on to successful accomplishment, as outlined in the following text and pictured in the accompanying illustrations. However, no chronological sequence in development is claimed, or one that is found in a single locality.

In these pages we will find that in no other industry has man obtained a greater mastery over the forces of the earth than in fabric making. For whether by means of the first awkward implements guided entirely by hand, or by means of highly developed self-acting tools obedient to power, he has so harnessed nature's forces as to utilize the life about him, both plant and animal, in supplying his need for textiles. Crude beginnings are always interesting, and no exception to this are the rude attempts of people of lower culture at yarn and cloth making. Life with them was very free and simple, while their daily wants did not exact arts of great complexity. At these rudimentary textile industries primitive man took a hand in some localities, and woman in other localities. How these native spinners and weavers so cleverly devised ways and means for handling the fibers about them will always remain a wonder. Admiration and wonder are aroused not only because of the marvelous feats accomplished, but because of pliability in the outcome. Mystery hovers near the birth of every practical invention be it primitive or modern; uncertainty, doubt, surround it. Will it prove successful? Will it efficiently meet the necessity?

Directly, or indirectly, these questions are of practical and universal interest, as much to the consumer as to the producer. But life did not remain simple. " When man became a civilized being his needs increased with his culture," and are still extending, an extension vividly reflected in his textile arts.

2 Yarn means to most of us the filaments of which cloth is made, its warp and weft. But twisted filaments had another and an earlier significance to primitive peoples, since twisted strands in the shape of lines, and lines worked into nets for fishing and trapping wild animals, as well as cords and string for fastening, joining and hafting, helped supply man's initial need for food. For purposes of this kind he first gathered slender trailing vines, twigs and grasses that grew about him, using them in their natural state. Later he learned how to prepare materials better fitted for binding, tying and sewing. Disintegrating leaves, stems and bark might easily have suggested the artificial extracting of vegetable fiber for this, while the skins and tendons from animals killed on the hunt might very naturally have suggested their stripping into thong and sinew for the same purpose.

**Early Spinning**

3 But whatever the function, or the material, these early cords and yarns were always twisted. We have no record of how twist first originated, or who was its inventor. But we do know that in a far distant epoch of the remote

**Origin of Spinning**

past some "untutored savage" did think out this greatest factor in spinning. Long before civilization dawned, early peoples had solved many of the fundamental difficulties connected with spinning, for wherever traces of prehistoric man have been found there are remains of spun threads, or of spinning implements. These prehistoric threads found many uses in fishing and hunting; for carrying earthen vessels and other heavy objects; in navigation, house building and cloth making. Indeed it was the art of spinning which first gave value to the art of loom weaving by supplying it with threads of any desired length, strength and flexibility. It is yarn for this use, yarn for loom weaving, that concerns us here.

4 Spinning consists of binding together a number of loose filaments into one strand by means of twisting.

**Spinning Defined**

Its object is to extend and arrange the loose fibers in a somewhat parallel order, and to bring them into close contact so as to impart greater strength and power to resist strain. To accomplish this, the material to be spun must pass through three processes: attenuation, twisting and winding. Attenuation pulls out the fibers lengthwise, arranging them more nearly parallel and lengthening the strand; twisting compresses the fibers so that they lie in close contact and binds them; winding cares for the spun yarn.

5 The essentials of good yarn are strength, firmness and solidity, qualities which require that the attenu-

ation be regular, that is, free from knots and weak places; that the twist be of the correct amount and evenly distributed; and that the relation between the degree of attenuation and twist be carefully adjusted. Twisting weakens fiber in proportion to the amount of twist put in, so in yarn it is not possible to secure the fiber's full strength. However, strength of yarn does not depend entirely upon the toughness of fiber, since the strain usually falls upon a longer stretch than the length of individual fibers. Weakness therefore results from a slipping of the filaments upon each other rather than from lack of inherent strength. It is the twist which remedies this slipping and makes twist such an important factor in spinning. Resistance to breakage strain in addition to the above ways may be secured by a sustained roundness and a uniformity in the diameter of the yarn.

**Yarn Characteristics**

6 Throughout the long period during which spinning was being brought to perfection, man worked for three objects: better yarn, more yarn and yarn produced at less expense. How these three were attained is traced here through spinning by hand, hand spindle, wheel, frame and machine. Attention will always be directed to the mechanical science involved and to the economic progress in the finished yarn. The unfolding from simple beginnings was slow, extending over centuries. At times long unbroken intervals of calm passed when advance was slight and

**Spinning Development**

improvement was gradual. Then sudden bursts of energy from some economic cause would produce phenomenal changes. The Industrial Revolution was such a period of progress and prolific invention.

7 Improvement in quality was dependent largely on more perfect methods of attenuation, twisting and winding, as observed under the Distinctive Characteristics and Improved Product of the various spinning types. Increase in output was controlled by a number of agencies. Prominent among these were the combining of the spinning processes, improved power, the perfecting of the spinning implement and its propelling mechanism, as seen under Distinctive Characteristics, Increased Production and Outline of the spinning types.

## Attenuation

**Drafting, Methods and Means**

8 The first process in spinning is attenuation, or drafting. It is of two kinds: drafting by stretching and drafting by drawing. In the first the tension is on greater lengths of rove and the draft more or less uneven and irregular, whereas in the second the tension is on shorter lengths and the draft more even. But the best method is a combination of the two, giving the rove both a drawing and a stretching. When considering the means employed in this process we find attenuation performed both by hand power and mechanically. Attenuation by hand power, as found in hand, hand spindle and wheel spinning, is

accomplished either by stretching or by drawing, or by a combination of the two. Likewise mechanical attenuation in frame and machine spinning is produced in the three ways.

**8a** In the simplest Hand spinning, attenuation is by
**8b** drawing, but in spinning by Hand-on-the-thigh, by the Grasped-spindle and by the Supported-spindle it is accomplished by stretching. The most perfect hand drafting is in

**Hand Drafting**

**8c** Suspended-spindle spinning, where the hand of the spinner draws the rove, while at the same time the spindle by its weight drafts it still further by stretching. This method produces the most faultlessly attenuated yarn the world has ever known.
**$8b_2$** It is true the finest yarn in the world is spun in India by the Supported-spindle. Nevertheless the perfection of this filmy cotton thread does not depend so much upon excellence of method as upon the expertness of the spinner of India. Her dextrous fingers possess a sense of touch most acute and delicate; and for finest yarns the spinner's age rarely exceeds thirty years. During spinning she uses a chalky powder to keep the fingers dry. If the thread is exceptionally filmy she must spin when the dew of early morning is still upon the ground and the air filled with moisture, or if this is impossible she must spin over water. Still, with all these contrivances the deft fingers do not succeed in drafting a thread of such uniform thickness as does the Suspended-spindle. Had this been the

case, instead of the Suspended-spindle which persisted over all Europe and the Mediterranean countries, we should have had a wide distribution of the
8d Supported-spindle. Drafting on the Asiatic and Jersey wheels, and on the Saxony wheel, returned to the less perfect method of attenuating by stretch-
8e ing. A distaff for holding the raw materials is occasionally used with the Supported-spindle, especially by tribes of eastern Asia and the adjoining islands. It is usually present with the Suspended-spindle and the Saxony wheel.

**Mechanical Drafting**

8f The first mechanism to take the place of the human hand in the delicate and complicated process of attenuation was not discovered until many centuries after a mechanical twisting device had been invented, and some time after winding had become automatic. Two devices for this appeared about the same time. The first was a moving carriage constructed for the new Spinning Jenny, which drafted by stretching. The
8g second was a roller mechanism for the new Water frame, consisting of a series of rollers, each succeeding set increasing in speed, which drafted by draw-
8h ing. This last proved so successful that later the Flyer, Cap and Ring spinning frames were built on
8i the same principle of drafting by rollers. However, this means did not make fine soft yarn needed for specific purposes. For the finer counts a new spinning implement was devised which combined the two kinds of drafting, first drawing the rove by a

series of rollers moving at different speeds, as on the Water frame; and then stretching it on an improved moving carriage. This implement is the Mule, which first took the form of the Hand Mule and later the Self-acting Mule run by power. It produces the most perfect mechanically drafted yarn.

## Twisting

**Twisting Implement**

9 As before noted, twisting is the important factor in spinning, since it is the process which gives strength and elasticity to the spun yarn by bringing the fibers composing it close together and binding them. Earliest twisting between the hands, or between the palm and thigh is laborious and slow; besides, in general it yields a coarse product, although research in northwest America shows that certain Indian tribes gained great dexterity in spinning by this crude method. Better and more expeditious twisting could only arrive with the development of mechanical science. This unfolding and growth showed itself in a diverse and varied way through the mechanics of twisting, first by the invention of a spinning device, the Hand spindle, and then by perfecting it. The earliest twisting devices which have been found among remains of ancient civilizations, as well as those seen to-day among the peasants and peoples of lower culture, exhibit the nicety to which the art of shaping, balancing and accelerating can be brought.

9c This perfecting culminated in the Suspended hand spindle, which spins in the air unretarded by friction. It has for centuries persisted throughout the ancient and medieval world, even down through modern times to the present day. Tomb paintings of the Middle Kingdom picture rows of Egyptian spinners making yarn by this method, and Greek vases depict the use of the same spindle. In fact no method of spinning has had so long and wide a distribution. Some authors hold that spindle spinning originated with this type in its crudest form of a single stick, or two crossed sticks, and used in each case as a Suspended-spindle. This may have been the earliest type in the Old World, but not in the New. Here, from the earliest times of which we have record, there have existed two more elementary

**Free Spindle**

9a types, both as to drafting and twisting. The first is the huge Grasped-spindle, which in a unique manner is grasped in both hands. Its spinning end is turned away from the spinner and twirled in the

9b air. The second type is a smaller and better adapted Supported-spindle. By some tribes it is revolved in a nearly horizontal position along the thigh. By other tribes it is twirled in a nearly vertical position between the thumb and fingers. The India spindle for Dacca yarn is of this type, and as has been said, spins the finest yarn in the world. It consists of a delicate iron, or bamboo shaft, weighted near its lower end with a small

ball, or wheel, of baked clay. The slender rove of short fibered cotton is so tender it would tear apart during the twisting if the spindle did not rest in a hollow shell. Next to the dexterity of the Dacca spinner in drafting is her skill in putting in an excessively close twist, which adds much to the durability of the yarn. This extra twist is due somewhat to the slender spindle of very light weight.

9d Mechanical science took a decided step in advance with the discovery that it was possible to mount the spindle. Thus came into existence the first mechanical spinning implement, the spinning wheel. India was the first home of this new twisting device, and it spread to different parts of Asia as well as Europe, where its form became slightly modified in the Jersey, or Wool wheel. A mounted spindle gives a steadier and consequently more certain twister than the free spindle, whose product is more or less dependent upon the dexterity of the spinner. The spindle's position is horizontal, which brings the spinning end conveniently toward the worker. In addition to stability, the mounted spindle allows the application of a mechanical means for rotating it. The principle of the pulley and endless band is applied in the shape of a large wheel, whose increased size over the small wheel holding the spindle greatly accelerates the twisting speed. This wheel is driven by hand, except in China where a propelling

**Mounted Spindle**

9e treadle is added. To the mounted spindle of the

Saxony wheel is added a flyer which twists the rove and passes it on to an independently moving bobbin.
9f This same spindle is used on the Water frame and the Fly, Cap and Ring frames, although in both it
9g is vertical. The spindle of the Jenny is the same shaft spindle of the Jersey wheel, as is also that of the Mule, although they are vertical.

## Winding

10 Caring for the spun yarn, or winding, is a very great economic necessity to prevent untwisting and tangling. The first winding was done by hand when the spun yarn was rolled into a ball. With the advent of the spindle this implement became the receptacle for the spun yarn and

**Winding by Hand**

10b has so remained to the present day. On the simplest spindles the yarn is wound by hand. First a length of yarn is twisted, then spinning stops until the spun length has been wound on the spindle, a kind of spinning termed intermittent, because the twisting and winding are separate motions. Winding was a very backward process in becoming automatic, although the Grasped-spindle makes a
10a crude attempt to assist in the winding. Here the huge spindle is rocked back and forth to loop on the spun yarn for the first winding, when it is removed from the spindle for the second winding by hand on the spindle shaft.

10c Attempts at automatic winding may be said to date back as far as the first Asiatic spinning wheel,

although no specific winding device is present, neither does the spindle help other than to turn, and to act as a receptacle for the spun yarn. The general mechanism allows winding by turning the drive wheel, if the stretch of spun yarn is moved so as to extend perpendicularly to the spindle, instead of out from its point as when

**Automatic Winding**

10d twisting. A similar spindle is found later on the multiple spinning frame, the Jenny. This permits winding by means of a moving carriage, which moves in toward the spindles, in imitation of the letting in of the spun yarn by the human hand on
10e the Wool wheel. Still later this same spindle is found on the Hand Mule and Self-acting Mule, where it is placed on a modified form of moving
10f carriage. The spindles of the Asiatic and Jersey wheels, the Jenny and the two Mules put twist into the rove, when twisting stops to give way to winding; then the yarn is wound on, when winding stops to give way to twisting the next stretch of rove. These alternating movements give the in-
10g termittent spinning. To return to the hand wheel, the Saxony spinning wheel has a new kind of spindle. In addition to twisting, it assumes the labor of winding by means of a freely moving bobbin which automatically winds on yarn as fast as twisted by the flyer. The double-functioned spindle introduces a new method of continuous spinning, since it allows twisting and winding without interruption.
10h This is also the spindle of the Water frame, a

multiple spinning frame with roller drafting and run by water or horse power. Again we find
10i the flyer spindle on the modern Fly spinning machine run by steam, and in slightly modified form on the Cap and Ring spinning machines of the same type.

## Developing Agencies

11 Early in the spinning industry an energetic agent appeared which greatly increased speed in yarn making. It was a combining of the processes. For in some types of spinning, the attenuating and the twisting may take place at the same time. In others the twisting and winding may combine. Indeed, in a few types all three
11a processes are reduced to one motion. In the simplest Hand spinning the three processes are
11b performed separately; but in the second variety of Hand spinning the drafting and twisting are done
11c at the same time. A backward step in this respect is taken in Grasped-spindle spinning, for the three processes again separate, as also in the crudest
11d variety of Supported-spindle spinning. However, in the second variety of this type the drafting and twisting are performed simultaneously, as also in Suspended-spindle spinning, and in the Jersey and Asiatic wheel spinning. The gain here is in quality as well as in speed, since yarn is generally stronger and more even when twist is put in during drafting, especially when short-fibered materials are spun.

**Combining Processes**

11e On the Saxony wheel all three processes are combined in one motion through the invention of the flyer spindle. This great victory in mechanical science was won by some unknown Saxony spinner.
11f The Spinning Jenny because of a non-automatic
11g spindle lapses to two motions. The Water frame has one motion, here the combined processes are drafting, twisting and winding from the automatic
11h spindle. In Mule spinning control in this particular gives way to a new problem, a dominant need for fine yarn; and the spinning again splits to three processes, to allow for yarn quality obtained only with double attenuation. The second drafting unites with the twisting and is possible only with the intermittent motion of the non-
11i winding spindle. With the Spinning frames there is again united action of the three processes, and a continuously spun thread. These, the most highly perfected spinning machines, have a speed truly phenomenal.

**Conserving Energy**

12 Another active factor which soon made its presence felt in the spinning industry is the economizing of human energy. In the earliest types it is of special interest to watch the freeing of the hands from the twisting process through perfecting the spinning means, or implement. In the most elementary Hand spinning both hands twist jointly; but in spinning with the Hand-on-the-thigh one hand only need twist, because the thigh supplies a stable working surface. The simplest

spindle spinning with the Grasped-spindle requires both hands to twirl the implement. But the Supported-spindle of smaller lighter shape adapted to support itself again frees one hand from the twisting, while the Suspended-spindle with still more perfect adjustment in size and heft releases one hand entirely and partially frees the second. In the earliest wheels, the Asiatic and the Jersey, one hand propels the drive wheel; but in the Saxony both hands are set free by the employment of foot power for propelling. Equally as interesting as conserving human energy is the avoiding of mechanical waste. An example of this is the eliminating of friction in various ways, notably its gradual lessening in the three types of hand spindles. The conserving of mechanical energy by effecting better action between the different parts of the implement, or machine, is but one of a number of means which will come readily to mind.

**Power**

13 Of very great importance to increasing production was the introduction of a more powerful means for propelling the spinning implement. Although spinning by hand power became quite successful as to speed in Suspended-spindle spinning, it was not until this free implement was finally mounted that much headway could be made toward increasing output. Even then it was with very great effort that early inventors were able to find a substitute for hand power, since the earliest wheels are propelled by

hand. With the Saxony wheel, it was discovered that the foot could supplant the hand as a driving force. This gain in improved power is traced in the spinning types through hand, foot, horse, water and steam power. With this last it is possible to manufacture an output of yarn such as is needed by the world to-day.

SPINNING TYPES

# I

## HAND SPINNING

*Distinctive Characteristics*

*A*. Simplest method of spinning: done entirely by hand. No device for any of the three processes.
Attenuating, twisting and winding done between the fingers, or palms.
Spinning processes performed separately, employing both hands.

*B*. Hand and thigh spinning: the two hands and thigh the means for spinning.
Attenuating done by left hand.
Twisting performed by right hand on thigh.
Winding performed by both hands.
Spinning intermittent: the attenuation and twisting simultaneous, followed by winding.

*Outline*

Examples: *A*. Peasants of Sicily; *B*. Koryak of Siberia; Tlinget of Alaska.

Implement — No artificial device.

FIG. 1. — HAND-ON-THIGH SPINNING, PHILIPPINE ISLANDS

The palm by one movement twists the two separate strands, then by a backward movement twists the two together into two-ply yarn.

*A*. The two hands (**1–7**).

*a*. fingers.

*b*. palms.

*B*. Hands and thigh.

Power — Hand (**13**).

Motion. —

*A*. Three separate motions (**11, 11a**).

1. attenuating.
2. twisting.
3. winding.

*B*. Two motions (**11b**).

1. attenuating and twisting (compound process).
2. winding.

Process — Drafting (**8b**).

*A*. with both hands.

*B*. with left hand.

Twisting.

*A*. between fingers, or two palms.

*B*. with right hand on thigh.

Winding with both hands.

1. Raw material drawn out into rude form of strand (**8, 8a, b**).
2. Drawn strand twisted (**9**).
3. Twisted strand (termed rove) wound into ball (**10**).
4. Rove again drawn and twisted for finished yarn.

### *Economic Gain*

The comparison here is of *B* to *A*. *A* is especially slow in manipulation, the length of spin short, the three processes carried on separately.

In production:

Longer spin, the distance between left hand and right thigh.

Simultaneous drawing and twisting, one hand freed from twisting, so that left draws while right twists.

Stationary thigh furnishes steady base upon which to twist.

In product:

More uniform yarn from steady base upon which to twist.

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# II

## GRASPED HAND SPINDLE

### *Distinctive Characteristics*

Simplest form of spinning implement: a spindle grasped in two hands.

Simplest attenuating device: a tension ring through which the rove is pulled to slightly retard it during the stretching.

Twisting device: large hand spindle with shaft and whorl.

No winding device: but spindle serves as appliance upon which to wind spun yarn.

Spinning processes performed separately with both hands.

### *Outline*

Example: Salish tribes of North America.
Implements — Grasped spindle with

1. shaft.
2. whorl.

Drafting ring.

*a.* stone.
*b.* wood.
*c.* wickerwork.

Power — Hand (**13**).

Motion — Three separate motions (**11, 11c**).

1. attenuating.
2. twisting.
3. winding.

Process — Stretching as rove is pulled through tension ring.

Twisting by spindle grasped in both hands (**12**).

Winding (*a*) with both hands, or (*b*) by swinging spindle grasped in both hands.

1. Rove prepared by Hand-on-thigh spinning.
2. A long length of rove pulled through tension ring (**8, 8b**).
3. Stretched rove twisted by rotating with a tossing movement the lifted spindle (**9, 9a**).
4. Twisted yarn after each length is spun (*a*) looped on shaft by raising and lowering spindle point, or (*b*) wound on spindle by hand (**10, 10a**).

*Economic Gain*

In production:

Greater length of spin.

Introduction of twisting implement releases hands from actual twisting.

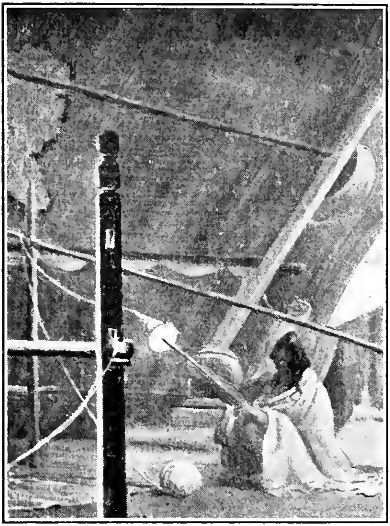

FIG. 2.—SIMPLEST SPINDLE SPINNING, SALISH INDIANS

The huge spindle twirled in air twists a long length of rove passing from a ball over a distant bar, instead of through the usual drawing ring.

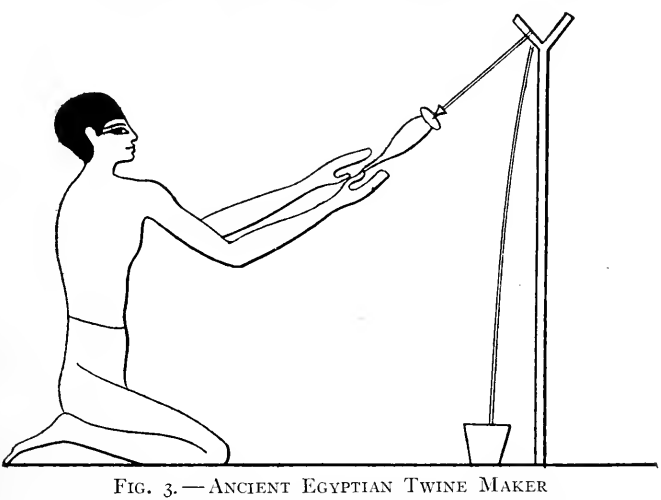

FIG. 3.—ANCIENT EGYPTIAN TWINE MAKER

The twine is twisted by a method similar to that of the Salish Indians.

Accelerating whorl for twisting does not stop when power stops as in Hand spinning; although the friction from manner of holding considerably retards rotation.

A loss from return to three separate processes.

In product: (no gain).

Poorer yarn, very much coarser than best yarn of Hand spinning.

Uneven from imperfect drawing.

Coarse from clumsy spindle.

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## III

## SUPPORTED HAND SPINDLE

### *Distinctive Characteristics*

*A*. Spinning implement: a smaller and less clumsy spindle resting lengthwise on the right thigh.

No attenuating device: left hand drafts.

Twisting device: hand spindle rotated by right hand.

No winding device: yarn wound on spindle-shaft with both hands.

Spinning intermittent: the twisting and winding alternating.

FIG. 4.—THE NAVAJO METHOD OF SPINNING

The Indian is drafting the rove preparatory to twisting, for which the upper spindle-arm is rolled along the thigh.

FIG. 5.—A KWAKIUTL INDIAN SPINNER

Here the lower spindle-arm is rolled on the lower leg for twisting.

*B*. Spinning implement: a small spindle standing erect on ground, in a shell, or in a cup.
Other details as in *A*.

***Outline***

Examples: *A*. Navajo; Kwakiutl; Pima; *B*. Mexican tribes; Some Philippine tribes.

Implement — Small supported spindle with
1. shaft.
2. whorl.

Power — Hand (**13**).

Motion. —
- *A*. Three processes separate (**11**, **11c**).
- *B*. Intermittent spinning (**11d**).
  1. attenuating and twisting (compound process).
  2. winding.

Process — Stretching with left hand (**12**).
Twisting with spindle controlled by right hand (*B* puts in more twist than *A*).
Winding with both hands.
1. Rove prepared by Hand-on-thigh spinning, or by modern hand cards.
2. Prepared rove, or carding, drawn out and fed to spindle (**8**, **8b**, **8b₂**, **e**).
   - *A*. before twisting.
   - *B*. while twisting.
3. Twisting.
   - *A*. Palm rotates spindle placed lengthwise on thigh (**9**, **9b**).
     - *a*. upper arm of spindle rests on thigh.
     - *b*. lower arm of spindle rests on thigh.

*B.* Fingers twirl spindle standing erect.
   *a.* standing in wooden thimble between toes.
   *b.* standing in clay bowl, or shell.
   *c.* standing on ground.

4. Spun yarn, after each length is twisted, is wound on spindle-shaft (**10**, **10b**).
5. This crude yarn generally respun for finished yarn.
6. Another spinning may be given for a fine yarn, or two single yarns may be doubled for two-ply.

### *Economic Gain*

In production:

*A.* Position of spindle removes a little friction and permits slightly more freedom to the accelerating whorl.

Loses by shorter length of spin.

*B.* Simultaneous drawing and twisting frees one hand from spindle.

Position of spindle removes all friction save at point, permitting good use of balancing and rotary power.

Greater speed from more even movement of smaller supported spindle.

In product:

More uniform yarn from better method of drawing and more even spindle movement.

*B* gives a harder twisted yarn than *A*.

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## IV

## SUSPENDED HAND SPINDLE

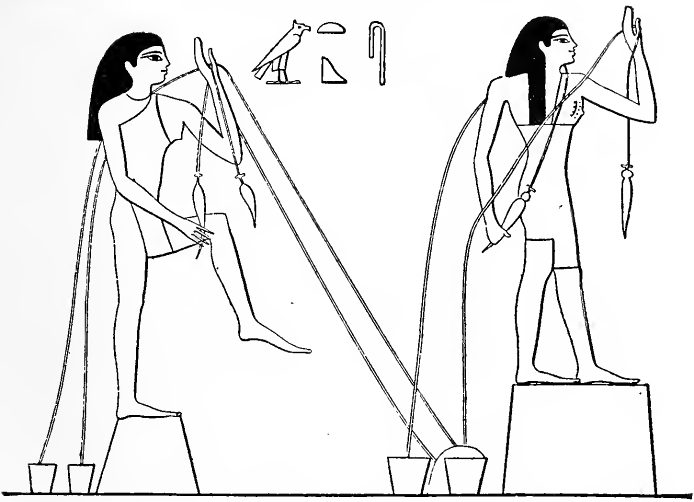

FIG. 6.—ANCIENT EGYPTIAN SPINNERS, MIDDLE KINGDOM

Right, spinner twisting simultaneously two lines of rove by rolling spindle on thigh. Left, dextrous Egyptian doubling yarn. Four single yarns are being twisted into two two-ply yarns.

### *Distinctive Characteristics*

Spinning implement: a spindle freely suspended from the thread it is spinning. A Distaff for holding raw material frequently present.

Attenuating device: spindle stretches rove after hands have drawn it.

Twisting device: hand spindle rotated by right hand and let swing.

No winding device: spindle used to hold spun yarn. Spinning intermittent.

FIG. 7.—SUSPENDED-SPINDLE SPINNING, HUNGARY

The flax is drawn from the distaff with one hand and the spindle twirled by the fingers of the other hand.

***Outline***

Example: Peasants of southern Europe, and tribes of Central Asia.

Implement — Suspended spindle.

*a.* a stone.

*b.* shaft with cleft, or hook.

*c.* shaft with cross bar and hook.

*d.* shaft with whorl and hook.

*e.* shaft with whorl, no hook.

Distaff frequently present.

Power — Hand (**13**).

Motion.—Intermittent (**11**, **11d**).

1. attenuating and twisting (compound process).

2. winding.

Process —

Drawing with both

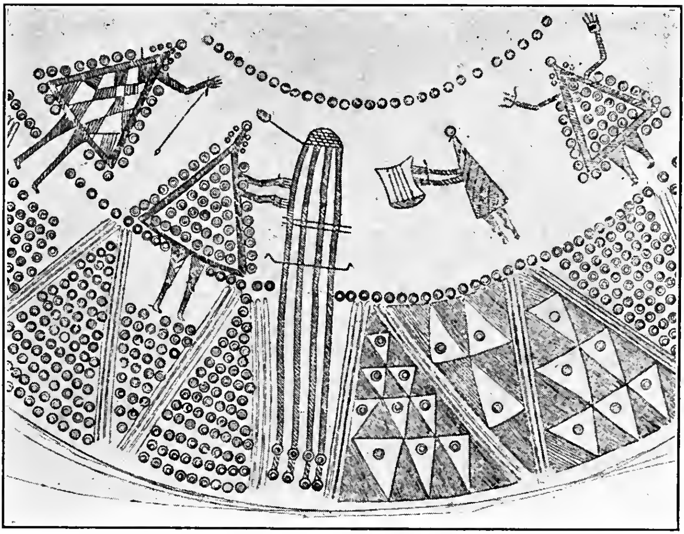

FIG. 8.—SPINNING IN THE ALPS, ABOUT 1000 B.C.

On the left is a quaint spinner with suspended spindle etched on the neck of an old tomb urn.

Fig. 9.—Winding Yarn on Spindle, Algeria

The spun yarn kept stretched by the spindle weight is first wrapped about the fingers as it is drawn in. Later it is unwrapped from them as it is wound upon spindle.

hands, followed by stretching with spindle. Drawing regulated by careful adjustment of spindle weight (**12**).

Twisting with spindle managed by right hand.

Winding with both hands.

1. Raw material attached to distaff held in left hand, under arm, or thrust into belt; or material made into loose carding, or rove.
2. Raw material, or rove, drawn out and fed to spindle which continues to stretch rove by its weight (**8**, **8c**, **8e**).
3. Spindle rotated by (**9**, **9c**).
   *a.* rolling with right palm on thigh and let swing.
   *b.* twirling between thumb and first finger and let swing.
4. Spun yarn wound on spindle shaft after each stretch is twisted (**10**, **10b**).
5. Yarn may be respun for harder twist, or doubled for two-ply, four-ply, or eight-ply yarns.

### *Economic Gain*

In production:

Greater length of spin.

Increased momentum of free spindle by eliminating friction.

Double means for drawing: the spindle and the entire use of one hand and part time of the other.

In product:

Yarn of great evenness, strength and delicacy.

Evenly attenuated yarn because of double drafting by the hands and spindle weight.

Of regular twist because twisted with tension, a close twist because of rapidly moving free spindle.

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# V

## JERSEY AND ASIATIC WHEELS

### *Distinctive Characteristics*

Earliest spinning contrivance worked mechanically: a spinning wheel with drive wheel and spindle; built on principle of supported hand spindle.

No attenuating device: left hand drafts.

First mechanical twisting device: a spindle mounted horizontally and driven by large wheel.

First mechanical winding device: spindle capable of winding on yarn.

Spinning intermittent.

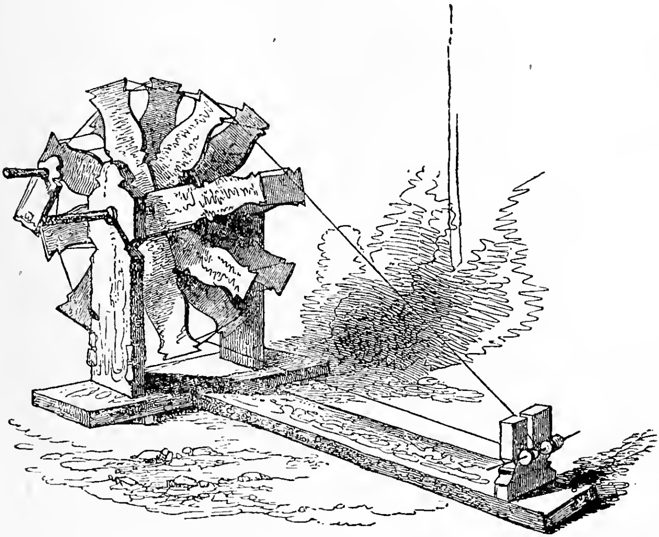

FIG. 10.—EARLIEST SPINNING WHEEL, INDIA

A mounted spindle is turned by a large hand-driven wheel by means of an endless band.

*Outline*

Examples: Jersey wheel, Europe; Teakwood wheel, Asia; Brunswick wheel, Europe.

Implement — One-band spinning wheel.

1. standard supporting spindle and drive wheel.
2. horizontal spindle parallel to axis of drive wheel (three spindles on a Chinese treadle wheel of this type).

3. large smooth-rimmed or one-grooved drive wheel which transmits power to spindle by single band.

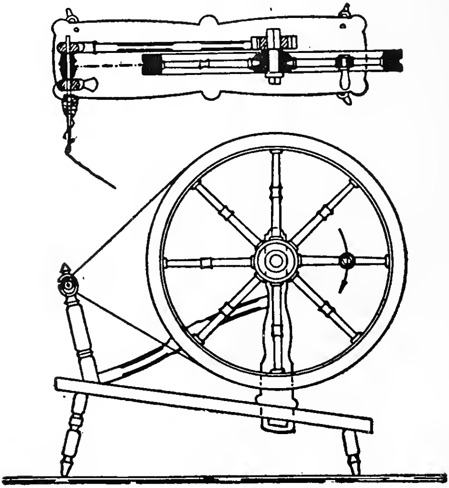

FIG. 11. — JERSEY HAND WHEEL, EUROPE

Wheel for wool or cotton. Top view shows spindle at left. Front view shows drive wheel propelled by hand and belt connecting wheel with spindle.

4. wheel driven by
   *a.* hand, or loose stick.
   *b.* crank.
   *c.* treadle.

Power — *a.* Right hand propels wheel (**13**).
*b.* Foot propels treadle wheel (Chinese).

Motion. — Intermittent (**11**, **11d**).

1. attenuating and twisting (compound process).
2. winding.

Process —

Stretching with left hand (**12**).

Twisting with spindle, left hand controls yarn.

Winding by spindle, left hand controls yarn.

1. Raw material made into loose carding.
2. Carding attached to spindle point and continuously fed to it as hand holds carding in a line with spindle point, while motion is given to drive wheel. Carding is stretched and twisted simultaneously (**8**, **8d**, **9**, **9d**).
3. When length of rove has been twisted it is brought at right angles to the spindle and wound on as the hand moves toward spindle (**10**, **10c**).
4. Coarse first spinning (rove) is respun for finished yarn.
5. Yarn may be respun for harder twist, or doubled for two-ply.

*Economic Gain*

Only a slight gain in output over Suspended spindle spinning, but the new invention leads the way for further advance.

In production:

Mounted spindle gives steady spinning.

Drive wheel and endless band assuring constant spindle rotation.

Large-size wheel propels smaller wheel, utilizing a multiplying power for greater speed.

Mechanical winding.

In product:

Coarser yarn.

Far less perfect yarn than the Suspended spindle gives with its double drafting and twisting with tension.

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# VI

## SAXONY WHEEL

### *Distinctive Characteristics*

Earliest spinning contrivance for carrying on all three processes continuously: a spinning wheel with automatic-winding spindle rotated by foot. A distaff may be attached or separate.

No attenuating device: both hands draft.

Twisting device: a spindle with flyer and independently moving bobbin.

First automatic winding device: the spindle-bobbin.

First continuous spinning: the three processes carried on simultaneously.

### *Outline*

Example: Saxony wheel of Europe.

Implement —

*a.* Two-band spinning wheel.

*b.* One-band spinning wheel (a later development).


Reproduced by permission from Hooper's *Hand Loom Weaving*, Macmillan, U.S.A., and John Hogg, London.

FIG. 12. — SPINNING COTTON ON SAXONY WHEEL

This treadle wheel, worked by foot power, frees both hands to draft the rove or carding of cotton. The spindle simultaneously twists and winds.

FIG. 13.—SPINNING FLAX ON SAXONY WHEEL

The flax is drawn from the distaff and drafted before passing it on to the spindle for twisting and winding.

1. Standard supporting spindle, distaff, drive wheel with attached treadle for driving wheel. (Exception: the Picardy wheel turned by crank.)

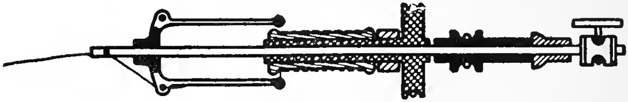


FIG. 14.—LEONARDO DA VINCI'S SPINDLE, 1500
(A drawing found in one of his sketch-books)

This spindle can simultaneously twist and wind. Bobbin (left of center) with large pulley (center) runs loosely on spindle shaft. Flyer (extreme left) and small pulley (right of center) are attached to spindle shaft. A band about each pulley rotates the bobbin and flyer at different speeds, while the end attachment (extreme right) regulates the position of bobbin and flyer during winding.

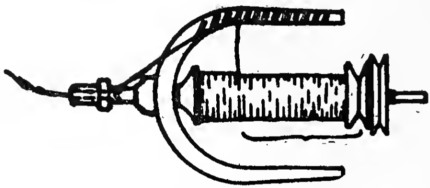


FIG. 15.—SAXONY SPINDLE, 1530
(The first fly spindle put to practical use)

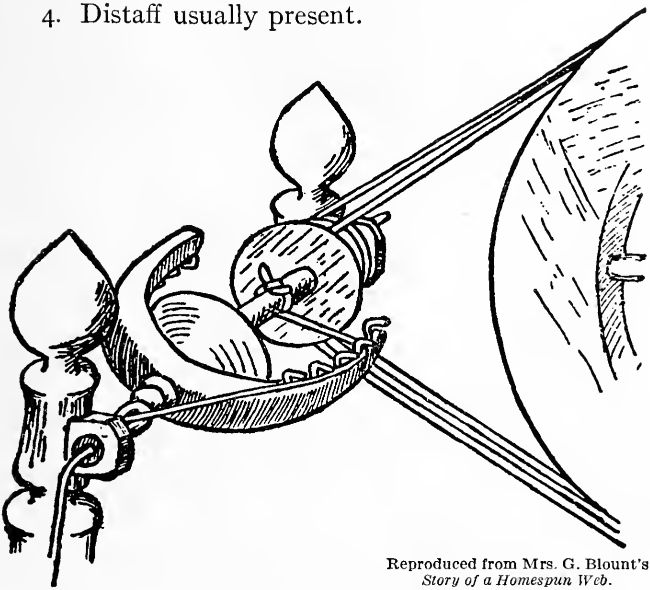
This more compact double-functioned spindle twists and winds continuously, spreading the yarn on the bobbin by a row of hooks on one arm of the flyer. The spinner from time to time shifts the yarn from one hook to the other. The flyer wheel (right) is larger than the bobbin wheel next it and so rotates less rapidly than the bobbin wheel.

2. Horizontal spindle supported at both ends, with flyer and bobbin moving at different speeds. (Later two spindles were placed on spinning wheel. Still later there was an automatic spreader for yarn.)

3. (*a*) drive wheel with two bands, one to spindle, one to bobbin.

(*b*) drive wheel with one band to spindle, drag of yarn retards bobbin.

4. Distaff usually present.



Reproduced from Mrs. G. Blount's *Story of a Homespun Web.*

FIG. 16. — THE SAXONY SPINDLE AT WORK

The rove to be spun is passed through the hollow spindle end and on to the flyer hooks when it is tied to the bobbin shaft. When the large wheel (extreme right) is turned, the two connecting bands give rapid motion to the flyer and more rapid to the bobbin. The flyer twists the rove and also spreads the twisted yarn on the bobbin, while the bobbin winds on.

Power — Foot propels wheel (**13**).
Hands attenuate.

Motion — Continuous, the three processes proceed simultaneously (**11**, **11e**).

1. attenuating, twisting, winding (triple process).

Process — Attenuation by hands (**12**).

Twisting by spindle-flyer.

Winding by spindle-bobbin.

1. Raw material pulled from distaff, or from carded roll in lap, and after attaching to spindle, it is fed to spindle, attenuating while doing so (**8**, **8d**, **8e**).
2. At the same time drive wheel turned by treadle rotates flyer and bobbin, which twist and wind on the spun yarn continuously (**9**, **9e**) (**10**, **10g**.)
3. Yarn may be respun for a harder twist, or doubled for two-ply.

*Economic Gain*

In production:

Greater speed given through division of labor by adding foot power to propel, and freeing both hands for drafting.

The double-functioned spindle automatically winds while twisting.

All three spinning processes simultaneous.

Distaff adds ease in caring for raw material.

In product:

Better attenuated yarn through the use of the thumb and fingers of both hands.

Rounder thread from passing through spindle opening.

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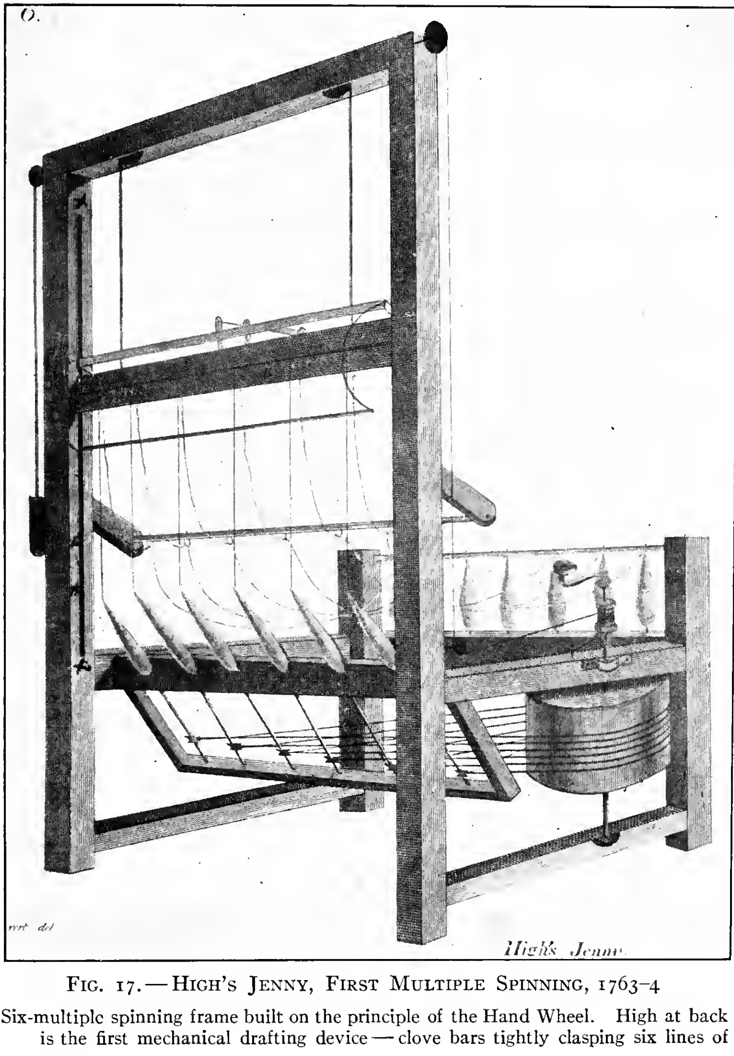


FIG. 17.—HIGH'S JENNY, FIRST MULTIPLE SPINNING, 1763–4

Six-multiple spinning frame built on the principle of the Hand Wheel. High at back is the first mechanical drafting device—clove bars tightly clasping six lines of rove.

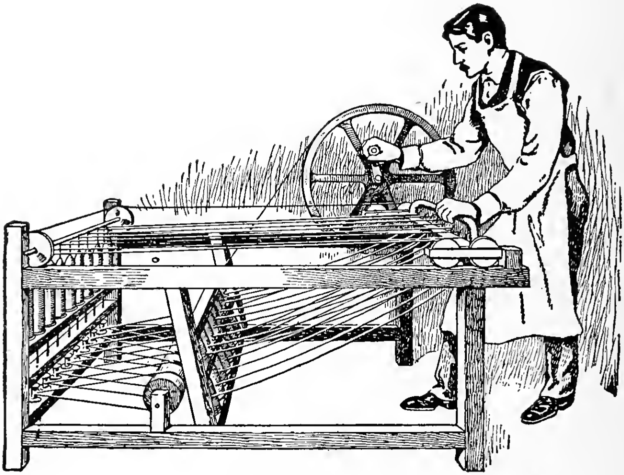

FIG. 18. — HARGREAVES' IMPROVED JENNY, 1767

Right, horizontal moving carriage with clove bars is shoved back and forth by left hand. Drive wheel turned by right hand rotates spindles by means of endless bands and a cylinder. Center, row of 8 to 16 rove bobbins. Left, row of 8 to 16 non-automatic spindles. The Jenny here is ready to wind; its carriage has drafted rove on its outward course and the spindles have put in twist; now they are ready to wind on with the inward run of the carriage.

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11. Dutch wheel.
Woolman and McGowan, p. 25. The flax wheel.
27. Detail of flyer.

## VII

## JENNY SPINNING FRAME

### *Distinctive Characteristics*

Earliest contrivance for spinning a number of threads and one which performs all three processes mechanically: a frame holding drive wheel, row of spindles, a moving carriage and row of rove bobbins; built on principle of Jersey wheel.

First mechanical attenuating device for stretched rove: carriage receding from spindles.

Twisting device: row of vertical spindles of the Jersey wheel type.

Winding device: spindles and the returning carriage.

Spinning intermittent.

### *Outline*

Example: Hargreaves' spinning jenny.

Implement — Spinning jenny.

1. frame supporting row of vertical spindles (Jersey wheel type), drive wheel, a moving carriage and creel of rove bobbins.

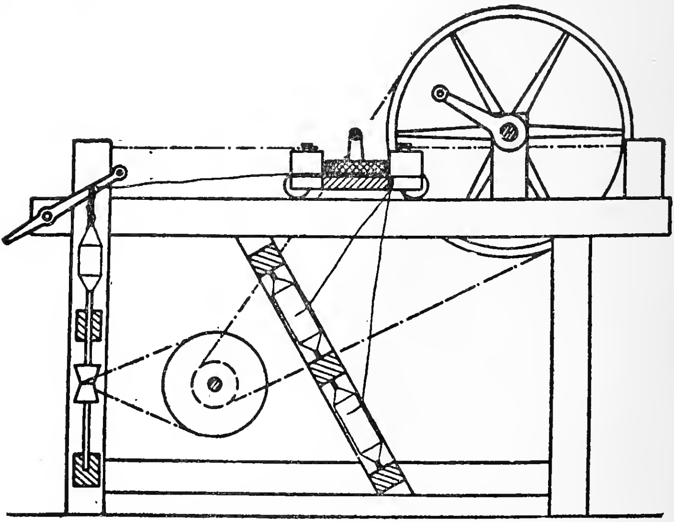

FIG. 19.—CROSS SECTION OF HARGREAVES' JENNY

The Jenny here pictured is ready to draft and twist. The carriage is starting on its outward run with the rove clasped between the clove bars. As the left hand moves the carriage outward towards the worker the rove between the spindles and clove is drafted. Meanwhile the right hand and drive wheel turn the spindles which twist the rove.

2. spindles with faller-wire at back of frame.
3. moving carriage with clove bars.
4. drive wheel turned by crank rotates spindles by means of band and cylinder.

Power — Right hand propels wheel (**13**).

Left hand moves carriage and faller-wire (earlier toe-managed faller-wire.)

Motion — Intermittent (**11**, **11f**).

1. attenuating and twisting (compound process).
2. winding.

Process—Stretching by moving carriage (**12**).

Twisting by spindle.

Winding by spindle and moving carriage.

1. Carriage placed in front of spindles and rove bobbins on creel, rove carried through clove bars to spindles.
2. Carriage recedes short distance from spindles measuring off length of rove to be spun, clove bars then close (**8**, **8f**).
3. Carriage recedes to end of traverse stretching rove, while spindles rotated by drive wheel give twist to stretched rove (**9**, **9d**, **g**).
4. Carriage stops, spindles put in more twist.
5. Carriage slightly backs, faller-wire drops carrying yarn from spindle-tip to winding position.
6. Carriage returns to spindles as spun yarn is wound on (**10**, **10d**).

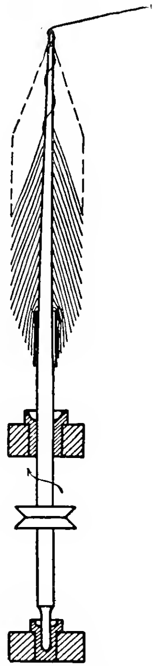

FIG. 20.—SPINDLE OF JENNY

This non-automatic spindle is like that of the Jersey Wheel. It intermittently twists and winds. (The spindle shaft and whorl are white.)

*Economic Gain*

In production:

Multiplication of threads, one person works a number of spindles, only

limited to strength and endurance of man to run machine.
Mechanical attenuation of yarn; limited to definite length.
In product (no gain):
Yarn not strong (inferior to that from Saxony wheel).
Quality of product not in proportion to quantity of product.
Inferior yarn from "stretch" attenuation.

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# VIII

## WATER FRAME

### *Distinctive Characteristics*

Earliest spinning contrivance where the three processes are mechanical and continuous: a frame with drive wheel, roller drawing device, and row of automatic-winding flyer-spindles so arranged as to move in unison and with power applied at one point; built on principle of Saxony wheel.

First mechanical attenuating device for drawn rove: a series of pairs of rollers moving at increased speeds.

Twisting device: row of flyer-spindles.

Winding device: the row of automatic-winding spindles.

Spinning continuous.

### *Outline*

Example: Arkwright's Water frame.

Implement — Water frame.

1. frame with row of vertical spindles, drawing rollers, creel of rove bobbins and driving mechanism.
2. flyer-spindles with automatic bobbin for building cop.
3. series of pairs of drawing rollers in front of rove creel.
4. cog-wheel, shaft and drum for driving.

Power — Horse power propels entire mechanism (**13**).
Later, water power.
Still later, steam power (1790).

Motion — Continuous (**11**, **11g**).

1. attenuating, twisting and winding.

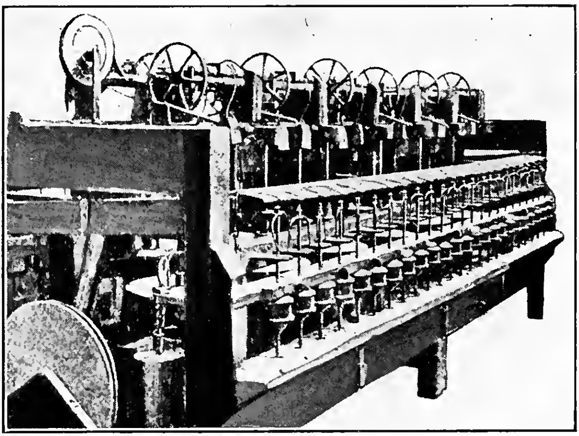

Fig. 21.—Arkwright's First Water Frame, 1770

The first spinning contrivance where all three processes are mechanical and continuous.

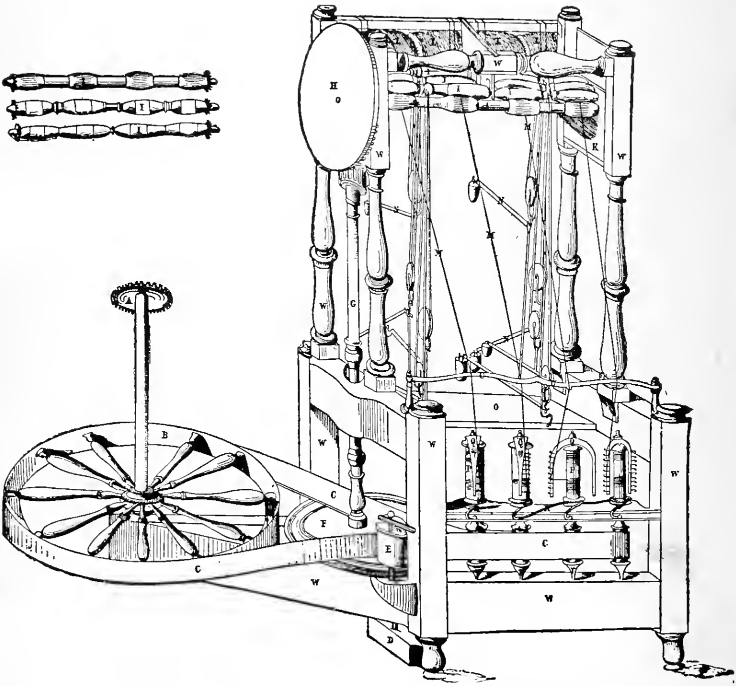

FIG. 22. — ARKWRIGHT'S IMPROVED WATER FRAME

Built on the principle of the Saxony Wheel, but with an improved method of roller drafting. Above, draft rollers. Below, flyer spindles. Left, wheel which propels the entire mechanism.

Process — Drawing by rollers (**12**).
Twisting by spindle-flyer.
Winding by spindle-bobbin.

1. Creel filled with rove bobbins, rove passed to drawing rollers.
2. Cog-wheel, shaft and drum set all parts of frame in motion.
3. Rove drawn as it passes between successive pairs of rollers moving at increased speeds (**8**, **8g**).
4. Spindle twists drawn rove as it comes from last drawing roller and winds twisted yarn on bobbin (**9**, **9e**, **f**, **10**, **10g**, **h**).

### *Economic Gain*

In production:
Mechanical working of all processes.
Union of all parts in concerted action.
Automatically winding spindle.

In product:
Not very fine yarn.
Hard twist, suitable for warp.
Strong and even yarn from improved attenuation by drawing.

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## IX

## HAND MULE

### *Distinctive Characteristics*

Earliest mechanical contrivance for spinning fine yarn: a frame compounded of the Water frame and the Jenny, with new form of moving carriage, bearing spindles.
First mechanical device for a double attenuation of rove: rollers for drawing and receding carriage for stretching.
Twisting device: row of spindles of Jenny type which twist while moving and while stationary.
Winding device: spindles on returning carriage.
Spinning intermittent.

*Outline*

Example: Crompton's mule.

Implement — Mule spinning frame.

1. frame with drawing device, headstock and moving carriage with spindles of Jersey wheel type.

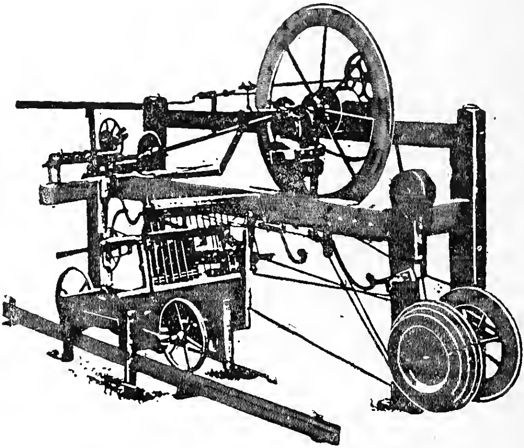

Fig. 23. — Crompton's Hand Mule

Crompton's Mule combined the best points of the Jenny and Water frame. Double drafting was secured by the drawing rollers and the moving carriage.

2. pairs of drawing rollers and creel of rove bobbins.
3. carriage that may be wheeled out and back with row of spindles.
4. headstock with driving parts.

Power — Hand; later horse; water for most of work.

Hand and knee managed carriage and the winding on.

Motion — Intermittent with three separate movements (**11**, **11h**).

1. Attenuating.
2. Attenuating and twisting. Twisting.
3. Winding.

Process — Attenuating first by drawing rollers and second through stretching by receding carriage (**12**).

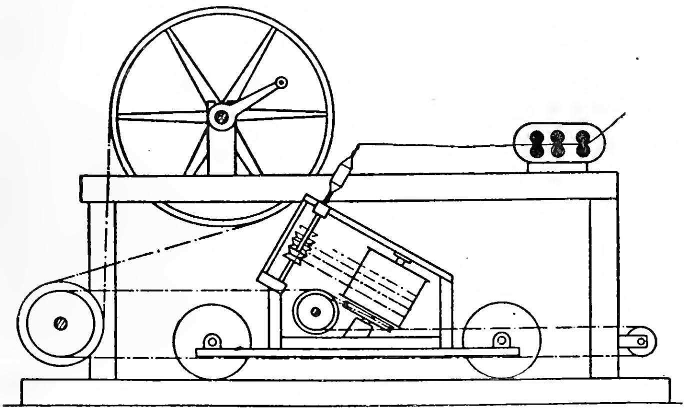

FIG 24.—CROSS SECTION OF HAND MULE

Upper right, drawing rollers attached to frame. Center, moving carriage with spindles. Upper left, propelling hand wheel.

Twisting by spindles.

Winding by spindles and returning carriage.

1. Rove bobbins placed on creel, carriage in front of rollers.
2. A short stretch of rove drawn from bobbins through drawing rollers to slightly faster receding carriage with slowly rotating spindles (**8**, **8i**, **9**, **9d**, **g**).

3. Rollers stop delivering rove and hold fast, spindles rotate more rapidly while carriage slackening pace continues to end of course.
4. Carriage backs a short distance to relieve strain on yarn; spindles add more twist.
5. Spindles stop; faller-wire drops carrying yarn from spindle tip to winding position (**10**, **10e**).
6. Yarn wound on rotating spindles as carriage returns to first position.

### *Economic Gain*

In production:

Spindles of Jenny transferred from standard to carriage.

Improved moving carriage.

A loss in speed from Water Frame, a gain over Jenny.

A loss in expense, mule required highly skilled manual labor.

In product:

Finer, more elastic superior yarn.

More evenly drawn because of combined roller and spindle draft.

More evenly twisted from stretch during twisting.

More gently spun, less strain on rove during attenuating.

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## X

## SELF-ACTING MULE

### *Distinctive Characteristics*

First machine for spinning fine yarn without manual help: the hand mule very much enlarged and perfected to work entirely automatically.

Attenuating device: pairs of drawing rollers and spindles on moving carriage.

Twisting device: row of Jenny spindles fitted with cop bobbins.

Winding device: moving carriage and spindles so adjusted to their varying speeds as to work automatically.

Spinning intermittent.

### *Outline*

Example: Roberts' mule.

Implement — Self-acting cotton mule.

1. machine with frame, headstock and moving carriage.
2. frame with drawing rollers and rove creel.
3. moving carriage with row of Jenny spindles fitted with cop bobbins and automatic faller and counter-faller wires.

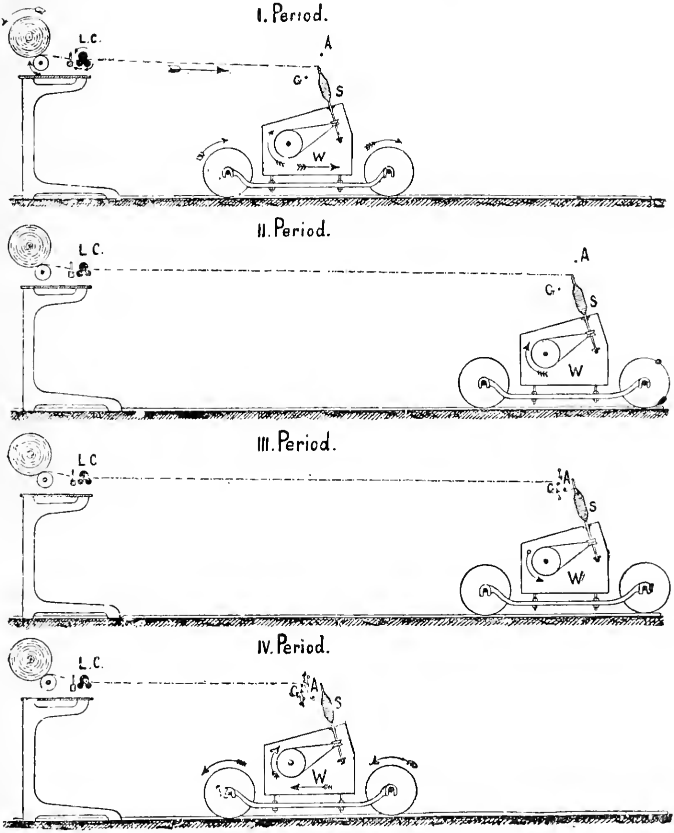


FIG. 25.—FOUR STAGES OF MULE SPINNING

4. headstock communicating motion to all parts, carefully adjusted to the many varied movements of machine.

Power — Steam (**13**).

Motion — Intermittent, with three movements (**11**, **11h**).

1. Attenuating.
2. Attenuating and twisting. Twisting.
3. Winding.

Process — Drawing by rollers and stretching by moving carriage (**12**).

Twisting by spindles.

Winding by spindles, faller and counter-faller wires on moving carriage.

1. Rove bobbins placed on creel, carriage in front of rollers.
2. Rove delivered to first pair of rollers and drawn as it passes between each succeeding pair, when it is delivered to slowly revolving spindles of the receding carriage which further lengthens it by stretching (**8**, **8i**, **9**, **9g**).
3. When carriage has covered some distance of path the rollers cease delivering rove and shut close; spindles revolve more rapidly while carriage moves to end of course.
4. Carriage stops a moment, spindles continue to add twist.
5. Carriage backs off short distance to ease high tension caused by increasing twist.
6. Carriage stops, spindles reverse rotation to pay off yarn wrapped about spindle point above cop bobbin, when two guide wires for winding on yarn assume proper positions.
7. Carriage returns to rollers, while spindles with aid of the guide wires slowly wind yarn on cop (**10**, **10e**).

*Economic Gain*

In production:

Higher spindle speed.

Admirable concert of all parts of machine.

Increase of spindles per machine.

Greater length wound on each cop.

But —

More complicated.

Requires more power to drive.

Requires greater intelligence of tender.

In product:

Finest and most perfect machine-spun yarn.

Better wound yarn.

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# XI

## FLYER, CAP AND RING SPINNING FRAMES

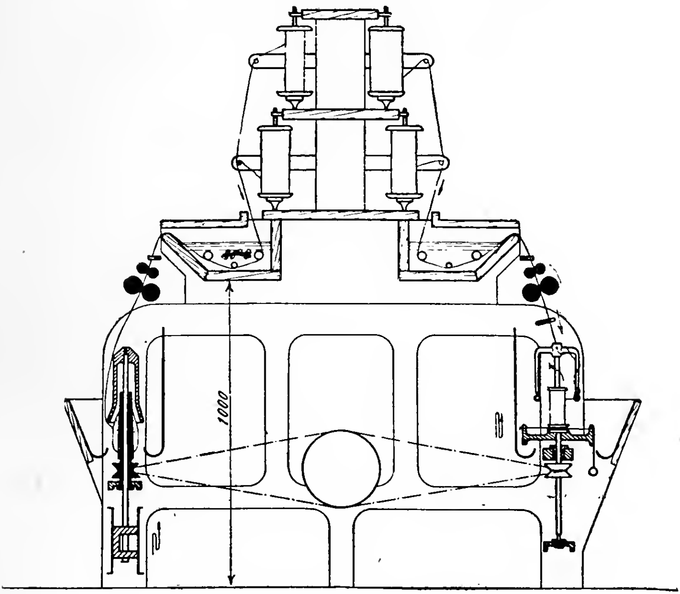


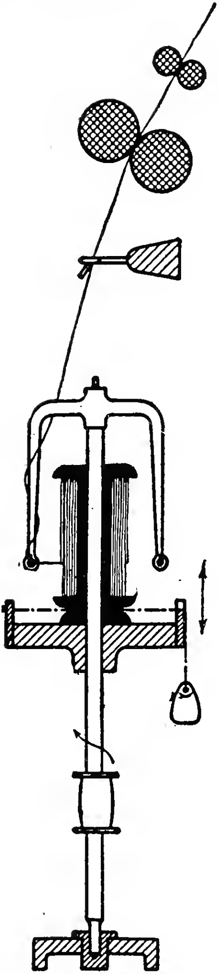

FIG. 26.—CROSS SECTION, FLAX SPINNING FRAME

The flax on its way to the drawing rollers is passed through a tray of water. On the left the twisting is by cap spindle, on the right by flyer spindle.

### *Distinctive Characteristics*

Perfected mechanical spinning frame: a spinning machine modeled after the Water frame, improved and simplified in its moving parts and run by power.

Attenuating device: series of pairs of drawing rollers.



Twisting device: the automatic flyer, cap or ring spindle.

Winding device: the automatic winding spindle.

Continuous spinning.

*Outline*

Examples: Flyer spinning frame; Cap spinning frame; Ring spinning frame.

Implements — Continuous spinning frames of the above type.

1. Frame with rove creel, draw rollers, spindles, driving mechanism.
2. Creel with rove bobbins.
3. Pairs of drawing rollers.
4. Row of spindles with tube bobbins.
   - *a.* flyer spindle, loose running bobbin, lifter plate.
   - *b.* non-revolving cap spindle, revolving bobbin, lifter rail.
   - *c.* ring spindle with attached bobbin, thread rail with guide wire, movable ring plate and ring with hook traveler.

FIG. 27.—FLYER SPINDLE

Drawing rollers which draft (above). Spindle and flyer revolved by whorl below (white) twist and guide yarn. Loose tubular bobbin (black) resting on lifter plate (gray) winds on.

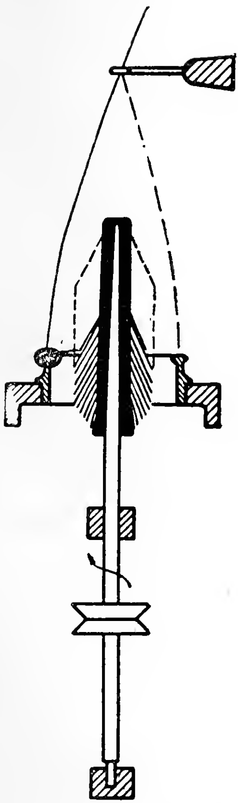


FIG. 28.—RING SPINDLE

Bobbin (black) firmly attached to spindle (white) which twists. Lifter ring plate (gray) with traveling hook; drag of yarn through hook winds on.

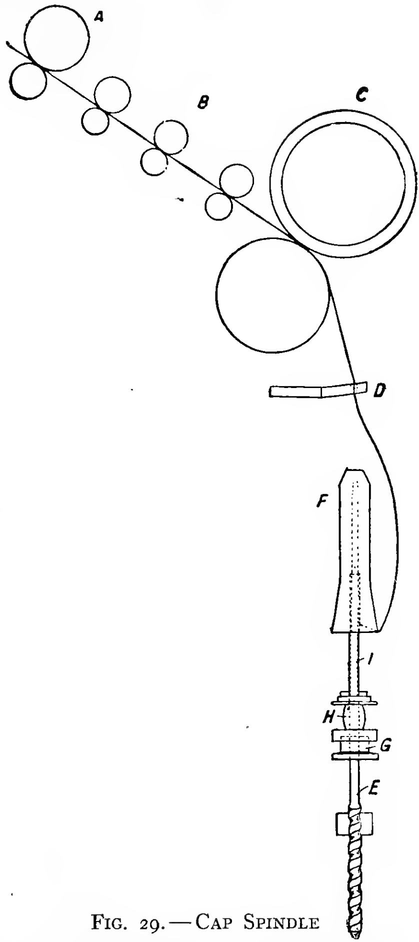



FIG. 29.—CAP SPINDLE

*F*. Cone-shaped cap attached to stationary spindle; the drag of yarn on cap-edge winds on.
*I*. Tubular bobbin revolving on spindle as axis is turned by hand about the whorl *H*; the bobbin twists.

Power — Water wheel, later steam (**13**).
Motion — Continuous (**11i**).
1. drawing, twisting, winding.

Process — Drawing by rollers (**12**).
Twisting by flyer, ring or cap spindle.
Winding by same.
1. Rove bobbins on creel pegs, rove passed to rollers.
2. Rove drawn between drawing rollers (**8**, **8h**).
3. Rove twisted between last rollers and spindle (**9**, **9d**).
4. Yarn wound on bobbin (**10**, **10i**).
   *a*. flyer revolving winds yarn in cop form on a dragging behind bobbin, as bobbin is raised and lowered by lifter plate.
   *b*. spindle and cap stationary and bobbin revolving builds cop as bobbin is lifted on rail.
   *c*. spindle and bobbin revolving in unison and traveler with drag builds cop.
5. Full bobbins doffed, frame filled with fresh empty bobbins.

*Economic Gain*

In production and economy:
Higher spindle speed.
Continuous spindle spinning.
Mounting more spindles on floor space.
Simplicity of machine requiring less repairs.
Employment of less skilled labor.
Less expensive than Mule.
Less labor.

In product:

Coarse yarns.

Superior strength, wiry smoothness.

Not so perfect or fine as Mule yarn.

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## CLOTH MAKING

15 Weaving is a very old art that for centuries has supplied mankind with clothing, and comfort in his home surroundings. Previous to man's attempt to weave, the spiders, caterpillars and birds skillfully constructed nests for themselves of a rough sort of interlacing, and so were the first weavers. Whether or not primitive man got his idea from these crude interlacings has not come down to us. He might as easily have obtained it from plant structure in peculiar tropical leaf and stem forms, such as the lace tree of South America. Some think he copied it from the interweaving of cut rushes which had been tramped over on the dirt floors of the rude huts; others believe he imitated the interlacing of date palm leaflets when crossed and tangled by the wind. In tropical countries to-day peoples of lower culture roof and side their crude shelters with these huge leaves, sometimes plaiting the leaflets, at other times letting them hang loose. In this last case they soon become so entangled as to suggest a surface little removed from rough matting. Whence the weaving idea came would be interesting to know, although were this possible quite probably

**Origin of Weaving**

we should find that in different regions it had developed from diverse sources.

Its source, however, is immaterial. The important thing is that primitive man did begin to interweave the coarse materials close at hand in his environment, such as pliable twigs, wide grasses and long palm leaflets. Of these weavings we have no record, for in the earliest accounts and among the most ancient remains the art appears in an advanced stage, thus furnishing no clew as to early method or origin. Its beginnings are lost in remote ages, for even in neolithic times there were skilled weavers. Between the first rude interlacing and modern machine weaving there is a vast stretch in time, and an expenditure of much energetic effort for attainment, since, as has been said, "Civilization's pathway is strewn with evidences of labor to compass the mastery of the industry." This struggle was not continuous, for as in yarn making, there are periods of great activity interspersed with long seasons of rest, since "weaving is an art and the motions of the art spirit are not along plodding levels of material things, but by leaps and flights." In the series of weaving types that follow only the most important developments are presented, with the accent upon the gain accomplished through each type as man responded to economic pressure with new devices to meet new situations. With his progress from savagery to civilization his needs multiplied

**Activity in Invention**

with advance in culture, so that now weaving no longer ministers only to the necessities, but also to the luxuries.

The present-day products of the loom are woven almost exclusively by the yard and handled in trade as piece goods, in yards of carpet, broadcloth, or muslin. Rugs and tapestries are an exception to this, but most weavings before coming into actual use must be cut and shaped, fitted and stitched, ere they are of service to mankind. Quite the reverse of this is the woven product of peoples of lower culture, most of whom weave their garments and furnishings entire, ready for wear and use without cutting, fitting, or stitching. Among these complete weavings are the poncho, the serape and the blanket of the American Indian.

**Basketry Weaves. Loom Weaves**

16 These loom weavings are to be distinguished from basketry plaiting and basketry weaving, which do not require a loom during their construction. Plaiting is begun by placing two or three loose rushes or other long strands on the ground in parallel position and crossing them by others with an interlacing, and then adding more strands to the left, the right, the near and the far sides. This possible progression in four directions distinguishes plaiting from weaving, which progresses in one direction only by the introduction of a weft strand which crosses a parallel series of warp strands. In plaiting there is no distinct warp or weft, as the strands plait in

four directions. It belongs to a large group of basketry technics which includes basketry weaving, but in none is an implement necessary to hold the strands during plaiting or weaving. The subject here is loom weaving of softer materials, which because of their flexibility require a frame, or loom, to secure the parallel warp strands during the weaving. In the crudest instances the materials may not be of spun or twisted yarns, as in the Ulmus-bark weavings of the Ainu and the Cedar-bark splint mattings of the American Indian of the Northwest.

**Weaving Defined**

**17** Barlow defines weaving as "an art by which threads of any substance are crossed and interlaced so as to be arranged into a perfectly expanded form." This well describes the finished product, but does not give an idea of the process, and besides, this definition might equally well apply to plaiting. A true definition will picture the row of parallel warp strands with the uniting weft strand moving back and forth across the warp. Such a definition might read: Weaving is a process which unites a series of parallel strands, or warps, by a crossing strand, or weft, which may interlace, wrap, or twine as it moves back and forth across the warp strands to form an expanded surface.

**18** Murphy aptly likens the warp to the "bone and muscle of the body" and the weft to "flesh and skin." To form this warp and weft structure

the warp strands, or foundation, must be arranged on the loom in a parallel series, a procedure termed *loom mounting;* while the weft strand, or filling, must be passed through the parallel warp strands to unite them, a procedure termed *wefting.* Each of these activities includes three processes. For loom mounting, the warp strands must be measured off into equal lengths and arranged in a parallel series, a process called *warping.* The strands must be secured to the beam or beams, the process of *beaming.* The weft strand when uniting the warp strands passes over and under certain warp strands, but in its second crossing it passes over and under the strands which before it went under and over. This would be a tedious process were it not for a mechanical device which raises and lowers the alternate warp strands across the entire width of the loom, thus making sheds for the passage of the weft. These sheds were prepared during the warping, making ready the warp strands to be connected with the shedding device, a process termed *heddling;* while the process giving motion to the heddles for opening the sheds is *shedding.* The movement of the weft through the shed is *picking;* and the beating close the weft strands is *battening.* In addition to these is a process termed *letting-off* and *taking-on*, which cares for the web as fast as it is woven, letting off unwound warp and taking on the woven web.

**Weaving Processes**

Thus we find that weaving includes more processes than spinning, since the manufacture of cloth means the handling of two sets of threads, the warp and the weft. This includes warp processes for measuring off the warp, for laying it and for preparing the shedding; beside weft processes for opening the sheds, throwing the weft and beating it up. All of these processes require specific devices either for warp manipulation or for weft manipulation. At first very simple implements were employed, but as time moved on they became more perfect and better fitted to the particular task in hand. To trace these important weaving improvements and developments is the pleasant undertaking of the next few pages.

## Warp Arrangement

19 Securing the warp strands in an extended and parallel position takes precedence over all other weaving considerations, since holding the warp in uniform arrangement is not only the first step in order but the most important one. No interlacing of threads can take place until the warp strands are in position. Many writers in classifying the different kinds of weaving describe the simplest as that with stretched warp, like Two-beam loom weaving. Or, if they mention some of the simpler types, they omit discussing this essential and earlier phase of textile development: warp arranging and stretching. The five earliest

**Warp Stretching**

types considered here are definitely concerned with the solving of this problem, the essential basis of all weaving, that of stretched warp strands held in parallel order and with equal tension.

19a On the One-beam loom the warp strands hang loosely from the one beam, secured only at their upper ends; and even this crude staying keeps them from
19b freely slipping about. In this particular, Weighted warp weaving varies slightly from the last type, since again the suspended warp strands are attached to the one beam at their upper ends. Here, however, a new device is introduced, a weight fastened to the lower warp ends to hold the strands taut. This is a decided step toward stretched warp, but there is still
19c much to strive for. The Two-bar loom presents an important advance, since here the warp is wrapped over two cylindrical cross-bars, or something which takes their place. The cross-bars are not true beams but serve merely as forms to keep the warp in a stretched position. In the Salish Indian loom of this type the warp does not pass over and over the bars, but over and back, turning upon a slender rod or a stretched cord. This rod or cord in reality is the true warp beam, making this a unique one-
19d beam loom. The Frameless two-bar loom uses the same non-revolving bars for stretching the warp, but they are free, one being fastened to a distant object and the other to the weaver's belt. When this narrow fabric or belt loom is in use, the horizontal warp is

**Devices for Warp Stretching**

held taut by the position of the weaver. When it it is not in use it is rolled up and stowed away for future weaving.

19e The problem of perfectly stretched warp is solved on the Two-beam loom, where there are present two beams, a warp and a cloth beam. Between these the warp strands are stretched. To primitive peoples is due the credit of perfecting this most important feature in weaving. No better method of securing the warp in a parallel and taut condition has been evolved than their method of stretching it between two beams. This arrangement is still employed on the modern loom of to-day.

**Perfectly Stretched Warp**

20 Turning to another warp problem, that of lengthening it for a longer web, we note that, although warp stretching became perfected with the Two-beam loom, warp lengthening for a weaving which exceeded the length of the loom was not fully accomplished before the Perfected hand

**Web Lengthening**

20a loom. The web from the One-beam loom is most elemental in length, for it is limited to the height of the loom. It is true that mattings of coarse flat materials may be twice the loom height, since the warp strands are suspended over the beam at their middle point. They hang to the ground on both sides and each is woven separately. All other weavings can be but once the loom height, since the warp is suspended below the beam and woven in

20b one. The ancient Weighted warp loom shows an

advance in that its beam revolves, apparently to permit a longer fabric. Still as there is nothing which indicates a means for extending the lower warp ends, we must conclude that the function of the revolving beam was to bring the work within easy reach of the weaver rather than for lengthening.

**20c** Webs from the Two-bar loom always measure twice the loom height, since the warp encircles the two bars, producing a weaving twice the distance between them.

**Means for Web Lengthening**

**21** Efforts to lengthen the web appear in different types. The One-beam loom and Weighted warp loom in general produce a web the height of the loom; the Two-bar loom produces one twice that height. Thus length in these simpler types is restricted by the size of the loom. Attempts to overcome this restriction took two directions: that of extending the warp to a distant point beyond the loom; and that of winding

**21a** a longer warp on a revolving beam. In the two frameless looms, the Frameless two-bar loom with its far and near bars and the One-shaft loom with its bunched warp ends and near beam, the parts are free and so admit a variety of lengths. This is possible because the far bar of the first loom and the bunched ends of the second are attached to distant posts, and the near bar of the first and near beam of the second are fastened to the belts of the weaver. So warp length in each case is determined by the weaver's position, although in

the first it is twice the length of the distance between the far post and the weaver.

**21b** These last two examples are quite similar to looms extending the warp beyond the frame, as in the Two-shaft treadle loom. In this method, the extension is usually run out in the direction of the warp end, or away from the weaver. But in a few localities in Africa the extension moves in the direction both of the warp end and the cloth end. Here the weaver sits at the side of the loom, since the lack of a revolving cloth beam prevents the ordinary position of the weaver. No locality in the world shows a greater diversity in mode of warp extension than India. Most outdoor looms of that country have very long warp, extending to a distant post, with an attached rope which passes about the post and back to the side of the weaver. This allows him to release more warp as needed without quitting his position at the loom. Indoor cloth making presents a more serious problem, especially if the weaving room is small, for then the warp must be looped up to the ceiling. If the weaving room is large the warp is extended as on outdoor looms.

**Extending Warp**

**21c** The second manner of lengthening the warp, that of winding the longer strands on a revolving warp beam, is an ancient method, but still used to-day. It has never been improved on, as shown in the last four weaving types, for it furnishes a perfectly stretched warp, with a length

**Revolving Warp Beam**

between beams only sufficient to get the needed warp movement for heddles and batten. Thus it allows a very compact loom and one requiring little floor space. Strange as it may appear, it is to ancient Egypt that we must go for the first example of this modern device. If we can correctly judge from ancient wall paintings, it is here that we have the earliest record of the revolving warp beam. In the New Kingdom, fifteen hundred years before Christ, this people had evolved for their simple Two-beam loom the method of procuring a longer web by the use of the revolving warp beam.

**Revolving Cloth Beam**

22 With both methods of warp lengthening, the extending and the coiling on a revolving warp beam, came the need of a revolving cloth beam to receive the finished web as fresh warp was either drawn in from the distant post or unrolled from the warp beam. Previous to the Two-beam loom, there were no distinct warp and cloth beams. In this type the cloth beam appears in two stages
22a of development. First, the non-revolving beam is found on vertical looms for short webs and on the simplest horizontal looms pegged to the ground, as in the Egyptian mat loom. Here for wefting, after the first short section, the weaver sits upon the
22b finished web. The second stage, the revolving cloth beam, occurs in its simplest form with the non-revolving warp beam. It is found on the horizontal loom pegged to the ground when it requires two weavers, one on each side; and on vertical looms

requiring but one weaver, who sits in front. An interesting case of invention in this particular appears on the Navajo loom. Its cloth beam is non-revolving. Feeling the need of some means to care for the finished web as sections of weaving are completed, the weavers lower fresh warp, and then fold the portion of completed web and stitch it to
**22c** the non-revolving beam. The free cloth beam of the One-shaft treadle loom is attached to the weaver's belt in such a manner that it may be revolved to take on freshly woven web, but in the One-shaft loom the beam is non-revolving, so that the belt web is pulled over the beam when finished and secured by an iron pin.

**22d** In the seventh, ninth, tenth and eleventh types of weaving both beams revolve, but only at intervals. When the cloth and the warp are to be freshly adjusted the weaver must stop wefting, and wind on the woven cloth and unwind new warp strands. On the Power
**22e** loom this is changed; the two motions become continuous and automatic. The cloth beam "takes-on" the woven web and the warp beam "lets-off" fresh warp without the assistance of the weaver and without his stopping the wefting. Thus with the continuously revolving automatic cloth and warp beams web lengthening was brought to completion.

**Automatic Beams**

**23** Ancient Egyptian weaving displays an interesting diversity in warp lengthening. As noted, the mat

weaving of this people admits a warp only the loom length, as both beams are non-revolving. The old linen loom of the Middle Kingdom depicted on the tomb wall at Beni Hassan, has repeatedly been described and copied, but frequently both copy and description are technically wrong. Latest researches have cleared up a number of facts concerning it, showing clearly that it is a horizontal loom pegged to the ground and supplied with a revolving cloth beam. Quite possibly it has a non-revolving warp beam and if so an extended warp. But this last is not certain, since the one illustration on the tomb at Beni Hassan is all that remains to judge by. The crude outlines suggest that the warp beam might have revolved, otherwise one set of the beam pegs would have had to be taken up and reset each time a short section of web was completed. This practice may have been resorted to, but it seems probable that these inventive weavers had thus early the revolving warp beam. The New Kingdom brought the vertical loom with improved warp arrangement on two revolving beams. Leaving ancient times, we find the Egyptian factory loom of the Middle Age shows an extended warp, such as is used in India. Here, however, it is not managed in the crude manner found in many parts of India, but the warp is perfectly stretched from a beam attached high on the side wall by two long ropes instead of one.

**Egyptian Web Lengthening**

## Wefting — Shedding

24 As the threads of a fabric do not all run in one direction, provision must be made for the second series, or the crossing weft-threads. Simplest wefting, as has been said, consists of the slow and tedious process of entering the weft under and over single warp strands. It was necessary to find a more rapid method and one which mechanically opened the two series of warp strands for the intersecting weft. This is shedding, a process second in importance only to warp stretching. From the earliest types there was a demand for such a process, although it did not become perfected for plain weaving before the Two-shaft treadle loom and for pattern weaving until the Jacquard loom. In early types a wish for greater speed and ease in manufacture forced the development of the process, but soon pattern making and later a desire for elaborate design necessitated even more perfect shedding contrivances. It is the manipulation of the lengthwise warp strands, for an easy passage of the crossing weft strand, which is the problem in shedding. Inserting the weft requires an entirely different kind of handling from that of warp stretching; it demands the greatest inventive genius as well as mechanical nicety, since the weft not only crosses the warp, but interlaces with it while doing so.

**Shedding**

25 As we have said, the simplest weaving, where each individual warp strand must be lifted and

lowered as the weft passes under and over, was abandoned by many early weavers because it required a separate movement for each warp strand. If two hundred warp strands are to be woven together it requires two hundred movements to carry the weft

**No Shedding Device**

25a across once, and one thousand movements to cross five times. Nevertheless, slow and fatiguing as is this first crude manner of laboriously lifting individual warp strands, it is still practiced by the American Indian of the Northwest. With supreme patience these Indian weavers, without a shedding device, fabricate blankets of most complicated design and beautiful texture.

**Shed-rod**

26 Many primitive peoples realized that for greater speed and ease in wefting a device was needed for simultaneously separating the two series of alternate warp strands to form an opening, or shed, through which the weft might pass with one movement. But such an opening was impossible with warp arranged as on the One-beam loom. Stretched strands or those approaching it were necessary, and these came with the

26a Weighted warp loom. The first step toward automatic warp shedding was probably the introduction of a flat sword-like rod under and over alternate strands, and then leaving it in place while the flexible weft was passed through the shed thus made. The rod was then removed and again entered under and over the opposite set of alternate strands, so

preparing a shed for a second line of weft. Without doubt, then came the thought of a permanent shed-rod for the first shed, although only a temporary one was possible for the second shed. Still even this arrangement saved half the work. Slow as is shedding by means of the shed-rod it persists among a few peoples of lower culture, some of whom insert a large number of slender rods to mark their elaborate pattern. Early weavers noted that in shedding the warp strands cross between the two sheds and that the crossing was necessary. Hence they began marking the warp crossing, or lease as it is termed, by two lease-rods, whose forerunners in all probability were the shed-rods above described.

**Shed-rod and Rod-heddle**

**26b** The difficult thing at this stage in shedding development was to find a device for raising the second series of warp strands, since only the first series was satisfactorily managed by the permanent shed-rod. Finally it was discovered that a flexible rod-cord-heddle, for convenience termed the rod-heddle, would successfully open the second shed, and when placed in front of the shed-rod would not interfere with the opening of the first shed, because of the looseness of its cord. This was a great advance over the exclusive use of the shed-rod, as it opened both sheds with the borrowed shed-rod and the newly devised rod-heddle. The invention of this method belongs to peoples of lower culture and was their dominant method of shedding. Although slow, it

was rapid enough for them, and in fact it was as far as aboriginal peoples developed the shedding process. Since it was a form incapable of developing beyond hand movement, the rod-heddle never carried over into modern weaving. Still the ancient Egyptians more than a thousand years before Christ employed this simple shedding device for manufacturing their famous linens and quite likely the Lake-dwellers of the Stone Age used a similar device.

**One Shaft-heddle**

26c The One-shaft loom introduces another style of heddle, a free shaft worked by hand, and employed almost exclusively for making belts and narrow fabrics. It combines in the one implement the work of the shed-rod and rod-heddle. In weaving a web of two hundred warps the single shaft-heddle separates the one hundred warp strands that the weft is to pass under from the one hundred that it is to pass over, so that the line of weft can cross the loom with one movement; then it again divides the warp strands so that the second line of weft can pass over and under the opposite strands. For this purpose the heddle is constructed of a single board cut by narrow parallel slits with intervening slats, each pierced at its center by an eyelet or hole. Likewise it may be made of a row of slender splints bound at their ends to two long horizontal bars and each splint pierced by a center hole as were the previously mentioned slats. These slits and eyelets furnish the

working parts of the heddle, since one series of alternate warp strands is entered into the row of eyelets and the second series into the row of slits, which allow this last series free movement up and down the vertical openings. When the shaft is raised, the first series of strands are held by the eyelets, while the freely moving second series pass to the lower ends of the slits, making a shed below the eyelet-held series. When the shaft is lowered, the freely moving series slide to the upper ends of the slits, making a shed above the eyelet-held series. Thus by this means the weft may pass quickly back and forth through first one shed and then the other.

**Shed-rod and Shaft-heddle**

**26d** The one shaft-heddle, although efficient for shedding the warp of narrow fabrics, was not suitable for wider ones because of greater difficulty from tangled strands. Especially troublesome is the warp when extending beyond the loom, and not wound on the revolving beam. Again the use of excessively fine threads for silks and muslins requires a more perfect shedding device. A separate contrivance for each shed and the two working independently was found necessary; a method which has continued in all later shedding. The One-shaft treadle loom employs a separate device for each shed and also two kinds of devices. It reverts in part to the old method with shed-rod and rod-heddle, but adopts instead of the rod-heddle a more efficient shaft-heddle,

giving a new combination of shed-rod and shaft-heddle. This is an old and almost extinct type found in a very limited area of China, Korea and Japan. Its most important innovation is the simplest form of foot power for working the shedding device. Here only one shed is opened by this means. A treadle ring for the toe, a treadle board, or a swinging slat lifts and lowers the shaft-heddle, while the shed-rod arranges the other shed. Ceylon uses a very simple loom of this type for making Dunbara mats, although here the shaft-heddle is worked by hand. There is no adjustment of the two beams, so the weaver is obliged to squat upon the woven portion. One shed is opened by the shed-rod and the second by a rude heddle attached by a cord to a tripod that can be shifted along from time to time as the weaving progresses. The hemp strips of weft are entered with a long lath which has an eye at one end, and are left with loose ends at either side. Another more primitive loom from the Bedouin desert, like the last is furnished with side supports upon which to rest the two ends of a rod which supports either the shaft-heddle or the rod-heddle, quite probably the last. (See Roth (1) p. 13.)

**Two Shaft-heddles**

26e To ancient weavers, and especially to those of the East, must be given the credit of bringing to completion the shedding process, by developing, if not by inventing, the shaft-heddle. The two factors responsible for perfecting shedding

are no doubt the desire for greater speed to increase output and for a more elaborate pattern which required very fine yarn. Ancient and medieval history are rich in allusions to the wonderful fabrics of silk, satin and velvet which came from Asiatic looms at this time. Elaborate weaving was possible only with heddle-shafts, frequently termed shedding-harness, or with the closely related heddle-cords of the Draw loom and the Jacquard. The Two-shaft treadle loom appears to have evolved in India and from there spread in all directions. It is found as far as West Africa, although there it is so crude as to suggest that it may be of native origin. Each heddle-shaft is constructed of two wooden laths joined by threads, which are passed from one to the other and looped at the center to form an eyelet through which the warp threads are run. The even threads pass through one heddle and the uneven threads through the other. These heddles are raised successively for shedding. When the first is raised it carries up alternate warp threads, thus opening one shed, and when the second is raised the second series of alternate threads are lifted, and the other shed opened. The employment of two shaft-heddles in place of the shed-rod and one shaft-heddle, furnishes a similar device for each shed. It is the most direct method of shedding, for with equal speed and certainty both sheds are opened, with the additional advantage that both are operated by

foot power. In the Perfected hand loom this method of shedding persisted throughout Europe during medieval and modern times until the Industrial Revolution. Even now it can be found in out-of-the-way places, used by the peasants.

**26f** Shedding for elaborate pattern making was first achieved on the Draw loom by a double harness which provided two kinds of shedding devices, a front harness for the shaft-heddles worked by treadles; and a back harness of free heddle loops, cords, or wires termed leashes, worked by a draw-boy. The warp strands were first threaded through the shaft-heddles, the eyes of which were made long, thus permitting freedom for the back harness to simultaneously or alternately affect the shed with the front harness. Then the same warp strands were passed on through the eyes of the free leashes, that these by their action might produce the pattern detail, as the front harness was producing the pattern in large. Later

**Pattern Shedding**

**26g** the Draw loom was superseded by the Jacquard loom, which simplified pattern making by means of a mechanism placed on top of the loom, worked by pattern cards, needles and hooks.

## Wefting — Picking

**27** Although picking is a wefting process not so difficult to master as shedding, it has had its problems. Weft was first inserted in short lengths that passed but once, or once and return, across the

warp in an under and over movement, or one that twined, or wrapped about the strands. Examples of these three methods of wefting short strands are shown in cleverly man-

**No Shuttle**

27a aged ways on the One-beam loom. With the use of softer materials, especially spun yarns, some people wove with a longer weft wound into a small ball. The need of lengthening the weft strand presented one of the earliest picking problems, since the short strands woven once across, or once and back, left a loose edge which easily unraveled. A continuous weft that could be carried across again and again provided two strong closed edges, since these journeyings of the weft to and fro formed a "selfedge" or selvage as it is termed. The Navajo weavers practice the method of making the weft into a small roll which they insert through the warp strands with their fingers.

27b The ancient Egyptians of the Middle Kingdom on the only cloth loom we know, employed short weft lengths that extended across the warp but once and return, and they probably inserted these strands by hand. Egyptians of the New Kingdom, however, had advanced sufficiently in the weaving art to employ a simple weft device, a long stick which measured the width of the loom and had a hook at one end. This device pulls the weft through the warp strands and also beats up the weft, thus serving the double function of shuttle and batten. There seems great

**Needle-Shuttle**

likelihood that this crude picking device evolved from the sword-shaped wooden batten, but there is no evidence. It is the simplest needle-shuttle, whose more perfect forms show a pierced eye, or a well-shaped slot, and in different areas vary from a long slender needle to a short broad one.

**27c** The simplest form of picking device which effectually meets the problem of a lengthened weft is the stick-shuttle. This truthfully merits the name of shuttle, or weft carrier, for it is loaded with many yards of weft wound endwise, crosswise, or diagonally. In furnishing a continuous weft the stick-shuttle is a long step in advance of the needle-shuttle. The latter can carry but a limited length and because free and extended it is liable to tangle. The stick-shuttle with its cargo of weft can traverse again and again through the sheds and form a strong selvage. In fact, this shuttle made its appearance with warp shedding, since it is not adaptable to wefting without a shed in which to pass. It varies in carrying capacity in different localities, and takes on numerous shapes which are usually more slender and shorter than the needle-shuttle.

**Stick-shuttle**

**27d** After a continuous weft thread had been attained, a second difficulty needed solving, that of a more smoothly moving weft carrier as it traversed the warp shed. The stick-shuttle wriggled more or less because of its awkward shape and from the unwinding weft, likewise

**Bobbin-shuttle**

it caught in the warp strands and the load of yarn impeded its progress. Finally some one devised a sheath, or case, in which to inclose a slender revolving quill wound with weft. The case took the shape of a boat and within revolved the bobbin of weft. The device probably developed from the stick-shuttle with a transverse winding, since the ancient Greek shuttle of Penelope needs only a case to make it a bobbin-shuttle. The Malay Islanders use a transitional type. Their shuttle consists of a slender rod, wound spool manner with weft, and covered with a removable slender case.

**Fly-shuttle**

**27e** The weaver threw the bobbin-shuttle from one hand to the other, a process very slow and employing both hands. However, this method continued in use for a very long time. The mechanical device finally invented was so planned that by pulling a string the shuttle shot from side to side. For the shuttle an artificial path was constructed, which consisted of a smooth shelf on the base of the reed batten with boxes at both ends to receive the shuttle as it moved to and fro. Here the chief difficulty was driving the shuttle with one stroke through the entire breadth of the warp. But when this difficulty was surmounted, the results were accelerated motion and the freeing of one hand for battening. Another gain was the possibility of weaving wider cloth without an assistant weaver.

27f Following the fly-shuttle came the drop-box arrangement for permitting the use of a number of shuttles with different kinds of weft. The end boxes of the shuttle-race were enlarged to contain two or more compartments, with a device which raised and lowered them so as to bring the desired compartment with its shuttle of weft on a level with the shuttle-race.

**Drop-box**

## Wefting — Battening

28 While battening is the last process in weaving and might seem of minor import, its significance is by no means slight. It has a task of its own to perform upon which good cloth depends. This process packs close together the lines of weft, making a firm, compact web, or an evenly wefted more open texture. Except in earliest, or finger battening, it arranges the weft lines straight and parallel, while in the more perfected forms it also distributes the warp strands in parallel and equidistant order. Its importance is understood when one remembers that many of the simplest looms, as the Egyptian mat loom, include only the batten in addition to the beams; this is the extent of the weaving apparatus.

**No batten**

28a The first battening was done with the fingers, which press home each line of weft, although these lines frequently are uneven. The short bodkin, or slender pointed stick, was an early tool for packing fine weft, especially in pattern making.

It is thrust between the warp strands, which drives home in a better way than do the fingers.

28b The almost universal batten or beater-in of peoples of lower culture the world over is the long thin sword-shaped stick batten. It is a very useful tool with a double function, for it assists in two weaving processes, the shedding and the battening. After each warp shed is opened the stick batten is entered flatwise, and then turned edgewise to widen the shed for the passage of the weft strand; when the shedding and picking for this line of weft is finished, the sword batten undertakes its second and chief work of beating up, by first being turned flatwise and then struck against the weft. With this tool, battening is a very slow process, since it is a free tool which must be entered anew with each line of weft, although as previously stated this means nothing to aborigines with whom time

**Stick Batten**

28c counts for little. The second task of another double-function tool, the needle-shuttle, is beating up the weft after it has been entered through the shed, but this cumbersome tool probably does not have a wide distribution. The sword-shaped batten is employed exclusively with hand shedding and rod-heddle shedding; it never carried over into shaft-heddle shedding or later industry. Frequently accompanying this batten in pattern weaving is the weaving comb, which assists in driving close short stretches of weft.

28d Progress in weaving invention brought the reed batten, a very great advance over the sword-shaped stick used for this purpose. It consists of a series of short vertical reed strips, or wires set the width of the warp and fastened in a frame. Between these reeds pass the warp threads, which are held by this means in a parallel series evenly dispersed and in such a manner that the web is kept of uniform width. For time saving, the value of a batten always in place in the warp is easily appreciated. The batten does not then have to be entered anew with each line of weft. This also distributes each warp thread in its appointed position, besides lessening the strain on the threads. The earliest reed battens hang loose

**Reed Batten**

28e on the warp threads; they are lightly attached by cords as in the ancient One-shaft heddle loom of
28f China. All later ones on hand looms are firmly sus-
28g pended from the top of the loom frame; and those on power looms swing from below. Some think the
28h crude weaving comb of aborigines suggested the reed batten, others believe that it followed the shaft-heddle when the textile inventor realized the value of evenly dispersed warp threads. Quite as possibly the reed warp spacer, such as was employed by the Ainu behind their shedding devices, may have preceded the reed batten.

## Loom Frame

29 The office of the frame differs from that of the devices which carry on the weaving. Its duty is

to support the working parts, that they may per-
29a form their function. Two types of looms, the Frameless two-bar loom and the One-shaft loom, are frameless, depending upon outside means for support. A belt passing about the waist of the weaver secures the cloth end of the strands, and a distant post, or the feet of the weaver,

**Frame Beginnings**

29b secure the warp end. The One-beam loom, the Two-bar loom and the simplest varieties of the Two-beam loom show only the beginnings of the loom frame in pegs, posts and hooks which serve as stays or supports. Two posts answer the purpose for the One-beam loom and the Two-bar loom, four pegs for the simplest horizontal variety of the Two-beam loom, and two cords and two hooks in the crudest vertical variety of the same type.

**Vertical Rectangular Frames**

29c The developing frame of the Weighted warp loom adds a couple of cross-pieces to stay its vertical uprights, a practice sometimes resorted to in the One-beam loom for heavy webs, as they might pull the uprights out of place. As we have stated before, the Two-beam loom may have no frame, or it may have stayings of very simple pegs, hooks or cords. But some of its vertical forms have a true frame, composed usually of four separate parts, two post and two cross-pieces, as on Navajo and a number of African looms. But these four parts at times are solidly united into a rectangular frame, as in the
29d Egyptian loom of the New Kingdom. Of necessity

the frame takes a rectangular form from the shape of the stretched warp strands. Notably the loom frames on the first, second, third and fifth types do not function perfectly, since here the frame does not support all the working parts. In these types it serves only to stay the warp by holding the beams. It is interesting to remember that with a very few exceptions, this is true of all vertical looms. This position does not lend itself to a perfect functioning frame.

**Horizontal Frame**

29e It was the horizontal frame, therefore, which claimed the attention of later inventors as the one best fitted to the working parts of the loom. When it is given this position
29f it begins to take on fresh duties. On the One-shaft treadle loom it holds the shedding and battening devices in addition to the warp beam, although it excludes the cloth beam to be attached to the
29g weaver's belt. On the Two-shaft treadle loom the frame relinquishes control over the beams and devotes itself to sustaining the weft devices for shed-
29h ding and battening. In the earliest forms of the Perfected hand loom the frame again supports the beams as well as the devices for shedding and battening, only omitting that for picking. But with the invention of the fly-shuttle this device was included, thus uniting within the loom frame all warp and wefting devices. As speed in weaving increased and the frame developed to include all working parts, its structure was greatly

strengthened and refined. For all parts required exact adjustment and good support to withstand the heavy vibrations of the various weaving processes, especially when the loom was driven by power.
29i The last three types of weaving show a slight variation in the shape of base from the Perfected hand loom; and the Draw loom and the Jacquard have greatly extended shedding devices which mount high above the rectangular base.

## WARPING

30 An important process in weaving is warping, or arranging the warp threads for the loom. For this they are laid parallel to each other in regular order and must be equal in length, as well as crossed twice to form two leases. Difficulty is experienced by the warper in keeping each thread separate with an equal tension throughout, especially for fine webs which may reach two thousand yards in length and have as many as
30a ninety threads to the inch. The simplest method of warping is practiced by northwestern tribes in North America. It consists only of measuring the yarn in proper warp lengths. It is not necessary on this loom to secure equal tension, as the warp strands hang loose, held only by their own weight. Neither is it necessary to prepare the two leases, as there is no shedding device to require leases. The warping device here is a simple measuring stick some five feet long with a few notches cut along the edge

**Simplest Warping**

near one or both ends. Around this stick the yarn is wound from end to end, or from end to a notch near the opposite end of the stick. When enough yarn has been measured off on the stick, it is cut and the warp strands are ready to be suspended from the one beam of the One-beam loom.

30b The first instance we know of effective warping, in the modern sense, is stake warping. A few

**Stake Warping**

stakes are driven into the ground at a given distance apart. The weaver with a ball or a bobbin of yarn in one hand, or one in each hand, then passes from one stake to another, winding the thread in parallel order from the ball or bobbin on to the stakes. Here the warp threads are laid with as equal tension as possible and the leases are carefully preserved. The Navajo use but two stakes in warping for their short webs but the weavers of India need more stakes for their longer webs. Indeed for these the stakes are often so set as to oblige the warper to travel almost round his house and back.

30c A very similar method to the last is warping on pegs driven into the wall, or into a warp-

**Peg Warping**

ing board. Again, the pegs are inserted into warping bars, a standing frame which leans against the wall. Later the warping device freed itself from wall support entirely in the bartrees, which with a support or standard may stand in any open space. Here the position of the peg, the important part, is horizontal instead of vertical, as were the warping stakes. Over the horizontal

pegs the yarn is more easily warped and with less exercise. At first when warping, a single bobbin or ball was held in one hand, or one in each hand; but later a number of bobbins were placed in a bobbin carrier, a small frame held in the hand. This device, with its few bobbins, increased the speed in warping so much that more bobbins were added to a larger and stationary frame or creel. From it a large number of threads were drawn and laid on the bartrees.

30d But it was not until after the expenditure of much effort through the 17th, 18th and 19th centuries that finally, by the invention of the warping mill, warping for fine materials like silk was made easy. The mill is a revolving cylindrical form of skeleton framework which takes the place of the warping bars. With it are a very much enlarged bobbin frame, or creel, and a heck through which the threads pass on their way to the mill. The heck spreads the warp threads evenly upon the reel and also holds a device for crossing the threads to form the lease. A newer mill revolves about a horizontal axis and it is claimed lays the warp strands with more uniform tension than the vertical mills. The two are

**Warping Mill**

30e turned by hand, although a later invention is a warping machine run by power and one which warps directly upon the beam. Recent discoveries record that ancient Egyptians of the New Kingdom had a warping creel and reel.

## Developing Agencies

It is not sufficient that each weaving process be perfect in itself; in addition to this it must be adjusted to the perfected mechanism of the other processes. For all parts are obliged to work together, pulleys, gearings, reverse gearings, check stops, etc., all mounted, fitted and balanced to a nicety, so as to move in perfect harmony. Weaving principles of necessity remain the same, the new and improved ideas are applied to the same weaving principles. The sequence of motions also remains the same for both the primary and secondary parts. To control these, especially at a high speed, the loom parts required strengthening and yet needed to be delicately regulated. Each change of movements, heddle shedding, shuttle picking, batten beating up, beams "letting-off" and "taking-up" meant adjustment and readjustment to keep all working in unison. This was more easy with hand power, but more difficult to govern with mechanical power.

**Perfecting Mechanism**

31 As the weaving industry expanded, it changed from a manual process to a mechanical one. The races of the East achieved the most perfect manual weaving and the peoples of Europe, transforming the crude loom implement into a machine, achieved the most complete
31a mechanical weaving. All types of weaving were done entirely by hand power up to the oriental type

**Power**

of the One-shaft treadle loom. From that type through the Two-shaft treadle loom, the Perfected hand loom, the Draw loom and the Jacquard, the looms were so harnessed and geared that the shedding process could be worked by foot power. But hand power still controlled the other processes.
31b The Draw loom with its double shedding required both foot power and hand power to manage this process, foot power from the weaver for the front harness and hand power from the drawboy for
31c the back harness. With the Power loom all processes were so unified as to be driven by one power; that power was steam.

## WEAVING TYPES

## I

### ONE-BEAM LOOM

*Distinctive Characteristics*

The most rudimentary weaving implement: a loom of one beam supported by two posts.

Warp device: a simple beam from which the warp is suspended.

Weft devices: none, the shedding, picking and battening done with fingers.

Weaving proceeds from above downward.

*Outline*

Example: American Indians of northwest coast.

Implement — One-beam loom (**15–18**).

1. frame, two vertical supporting posts (**29**, **29b**, d).
2. one-beam, non-revolving (**19**, **19a**, **20**, **20a**).
3. no shedding device (**24**, **25**, **25a**).
4. no picking device (**27**, **27a**).
5. no battening device (**28**, **28a**).

Warping device — measuring stick (**30**, **30a**).

Power — Hand (**31**, **31a**).

Process — Loom mounting.

FIG. 30. — ONE-BEAM LOOM, NORTH AMERICA

The warp strands of bark strips are hung loosely over a beam supported by two posts. The weft is run in over and under the warp strands without a shedding device.

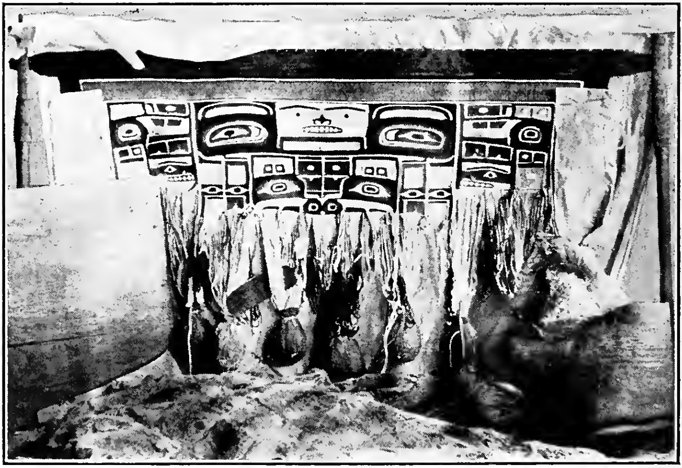

Fig. 31.—Wool Weaving on One-beam Loom

This Chilkat blanket in process of making is not in plain over and under weave but of twined weaving. The warp strands hang loosely without stretching as in Fig. 30, and no shedding, picking or battening devices are used.

Warping — warp wound on measuring stick and cut from stick in strands.

Beaming.

*a.* warp strands suspended over beam.

*b.* warp strands suspended over headline attached to beam.

Heddling, none.

Wefting.

Shedding, Picking, Battening — done with fingers.

*a.* one weft strand interlacing.

*b.* one weft strand wrapping.

*c.* two or more weft strands twining.

FIG. 32. — MEASURING STAFF

Over this stick from end to end the warp yarn is wrapped to obtain the required length of warp strands.

*Economic Gain*

Here the usefulness of the device must be summarized without comparison. For uniformity the items are grouped as in the succeeding types.

In production:

The one beam helps stay the warp strands at one end.

It serves both as warp beam and cloth beam.

In product:

More even technic than if without loom.

A great variety of weft arrangements possible from warp stayed at one end.

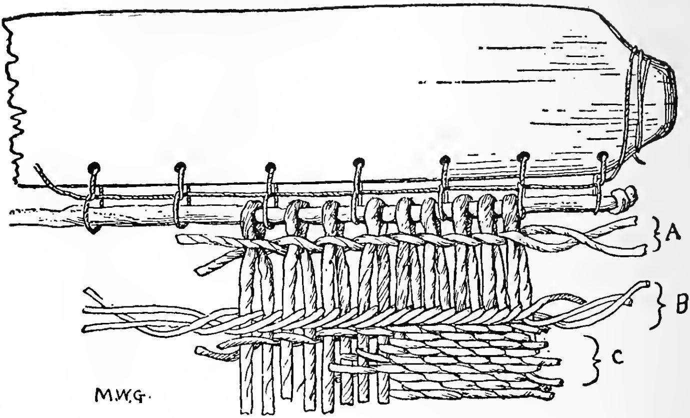


FIG. 33.—METHOD OF ATTACHING WARP TO BEAM

The loom beam is flat with pierced holes, through which runs a cord to attach the headline, over which are suspended the soft warp strands. Below the headline is a row of plain twining (*A*), of two strands which twine about the warp. Farther down is a border of three-ply twine (*B*), adjoining which is a square of twilled twine (*C*), the body weave of the Chilkat blanket.

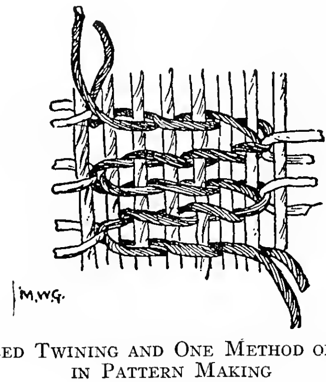


FIG. 34.—TWILLED TWINING AND ONE METHOD OF JOINING STRANDS IN PATTERN MAKING

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6. Old Chilkat blanket.
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## II

## WEIGHTED WARP LOOM

### *Distinctive Characteristics*

Weaving implement: one beam loom with weighted warp strands.

Warp devices: one beam and warp weights.

Weft devices: shed-sticks, or a shed-stick and one or more rod heddles for shedding; stick shuttle for picking; at times a sword-like stick for battening.

Weaving proceeds from above downward.

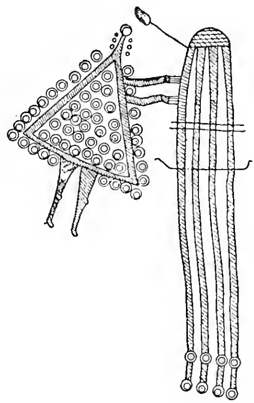

FIG. 35.—AN ALPINE WEAVER, ABOUT 1000 B.C.

Scratched on an old tomb urn from the eastern Alps is this loom with no frame pictured to show its character, but it must have been similar to that of the early Greek loom. Weights stretch the warp, and a shed-rod and rod-heddle part the warp strands.

### *Outline*

Examples: Ancient Greek; Icelandic; Ancient Lake-dweller weaving.


*Reproduced by permission from Hooper's "Handloom Weaving." Macmillan, U. S. A. and John Hogg, London.*

FIG. 36.—GREEK WEAVER, 500 B.C., BRITISH MUSEUM VASE

"The legend is of Circe at the moment when the Sorceress is in the act of offering the noxious potion to Ulysses." Hooper.

Implement — Weighted warp loom.

1. frame — two vertical posts and crossbar (**29**, **29c**, **d**).
2. warp device (**19**, **19b**, **20**, **20b**).
   (1) one-beam supported on upper ends of frame posts.
      *a.* non-revolving.
      *b.* revolving.
   (2) warp weights.
3. shedding device (**24**, **25**, **26**, **26a**, **b**).
   *a.* two rods.
   *b.* shed-rod and rod-heddle.
   *c.* shed-rod and three rod-heddles moved by lever over cross-bar.
4. stick-shuttle (**27**, **27c**).
5. batten — sword or paddle-shaped stick (**28**, **28b**, **c**).

Power — Hand (**31**, **31a**).

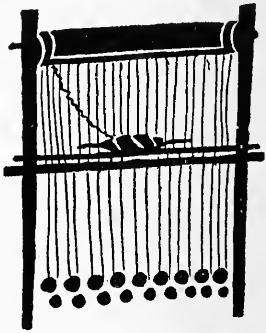

FIG. 37.—CIRCE LOOM ON GREEK VASE IN ASHMOLEAN MUSEUM.

Weighted warp strands, revolving beam, stick-shuttle and probably shed-rod and rod-heddle are all present.

Process — Loom mounting.

Warping, over stakes (**30, 30b**).

Beaming, warp lengths suspended from beam.

Heddling.

1. shed-rod entered through warps.
2. heddle-rod laid across warp and laced by cord to back series of alternate warp strands.

Wefting.

Picking, Shedding, Battening.

*a*. by hand.

*b*. as in Frameless two-bar loom.

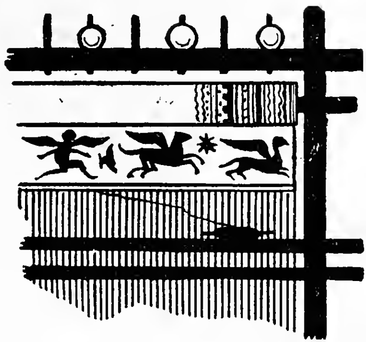

Fig. 38. — A Bit of Penelope's Loom, 500 B.C., from an Etruscan Vase, Chiusi Museum

A portion of the cloth already woven has been wound on the beam; below it is a decorative border with the stick-shuttle ready to weave farther.

*Economic Gain*

In production:

Warp weights hold warp more taut.

Introduction of shedding, picking, and battening devices.

In product:

Web coarse but finer than previous type.

Lines of weft more nearly horizontal from shedding and battening devices.

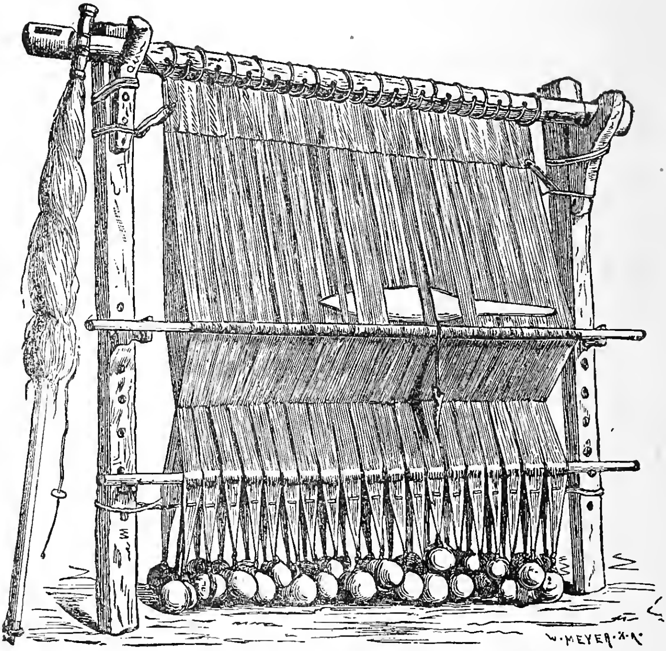


Fig. 39.—Scandinavian Weighted Warp Loom.

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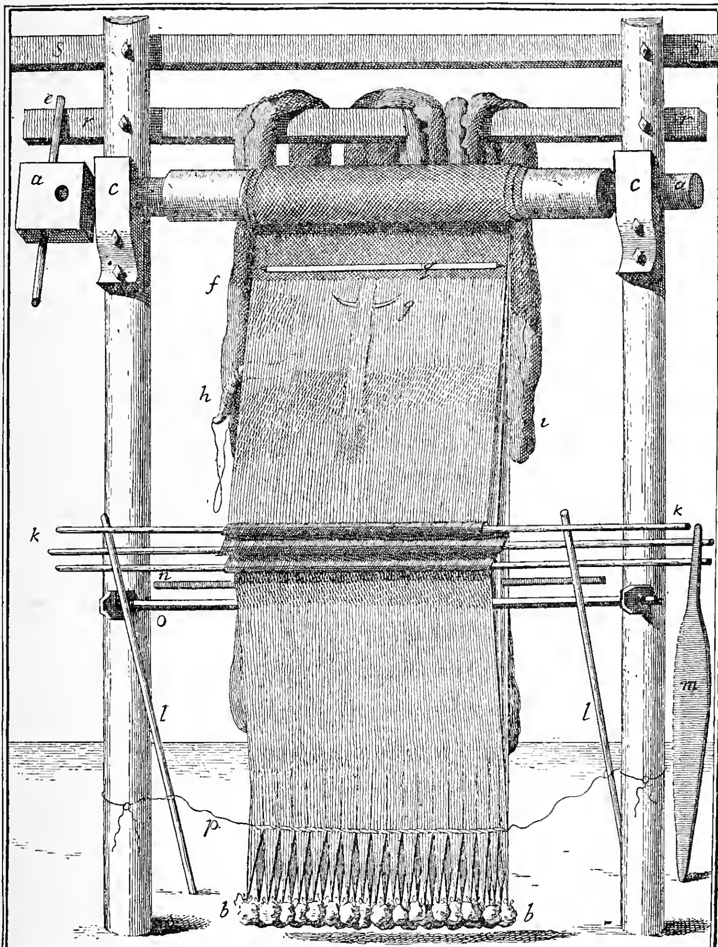


FIG. 40.—WEIGHTED WARP LOOM OF ICELAND.

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# III

## TWO–BAR LOOM

### *Distinctive Characteristics*

Weaving implement: a loom with two non-revolving bars supported by side posts (a transitional type between the suspended warp loom and the perfectly stretched warp loom).

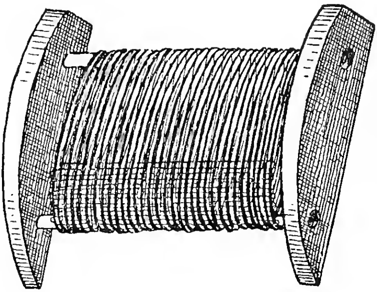

FIG. 41.—SIMPLE TWO-BAR LOOM, SOUTH AMERICA

The warp is wrapped round and round over the two bars.

Warp devices: two non-revolving bars over which the warp is wrapped from one to the other.

Weft devices: fingers perform shedding, picking, battening (except in Africa).

Weaving proceeds from below upward, or from front backward.

### *Outline*

Examples: Salish Indians; Calabar, W. African; Tereno Indians; Holamux Indians; British Guiana apron weaving.

Implement — Two-bar loom.

1. frame (**29**, **29b**, **d**).
   *a*. two heavy posts which hold ends of bars.

*b.* two posts support cross-stick from which the upper bar hangs, the lower hangs in warp strands.

*c.* no frame.

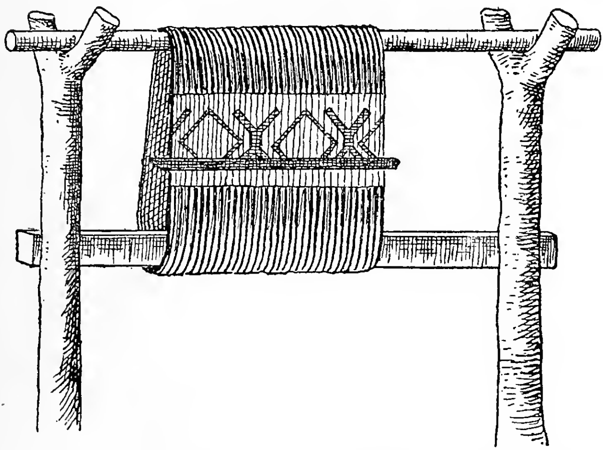

FIG. 42.—ANOTHER CRUDE TWO-BAR LOOM FROM SOUTH AMERICA
Here two tree trunks serve as frame posts, while the warp itself supports the lower bar.

2. bars — non-revolving, held in place by small wedges or ropes (**19**, **19c**, **20**, **20c**, **21**).

   *a.* two straight bars.

   *b.* two bars, one bent and joined to the other to form the letter D.

3. heddles (**24**, **25**, **26**, **26a**, **b**).

   *a.* none, fingers perform shedding.

   *b.* shed-stick and one or more rod-heddles (Afr.).

4. shuttle (**27**, **27a**, **b**, **c**).

   *a.* none, fingers do the picking.

*b.* long stick with hook or eye (Africa).
*c.* stick-shuttle (Africa).
5. batten (**28**, **28a**, **b**, **c**).
*a.* none, fingers do the beating up.
*b.* none, stick-shuttle performs process.
*c.* sword-like stick.
Warping device (**30**, **30b**).
*a.* none.
*b.* stakes.

Power — Hand (**31**).

Process — Loom mounting.

Warping (none), warp laid over bars without measuring off; *b.* laid on stakes.

Beaming.
*a.* warp wrapped over and over beams.
*b.* warp wrapped over beams to back and there turned in the opposite direction over a slender rod, or cord (this rod or cord is in reality the warp beam).

Wefting.

Shedding.
*a.* none, fingers raise and lower individual warp strands.
*b.* shed-stick and rod-heddle as in Frameless two-bar loom.

Picking, weft passed through warp strands by fingers or by stick-shuttle.
*a.* over and under one warp strand (plain weave).
*b.* over and under two warp strands (twill weave).

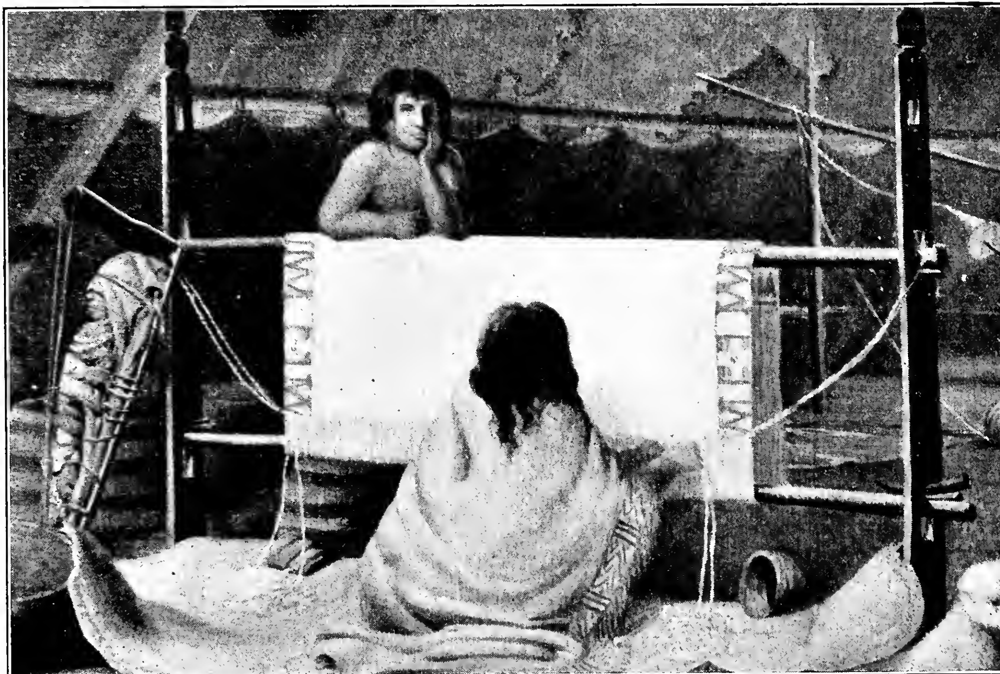

FIG. 43.—SALISH INDIAN FAMILY SCENE. BLANKET WEAVING

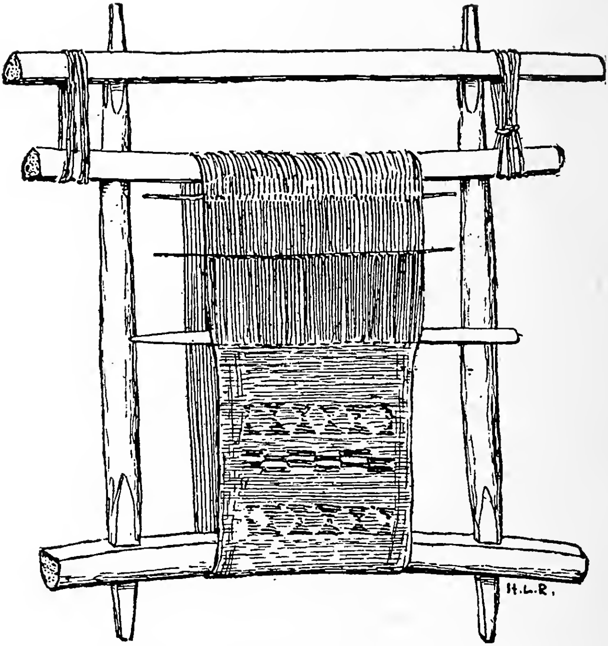


FIG. 44.—TWO-BAR LOOM, WEST AFRICA

The most advanced loom of this type is in Africa, where patterns are introduced in overlay (an exceptional form).

Battening.

*a.* weft beaten up by fingers.

*b.* weft beaten up by stick-shuttle or batten.

Warp adjusting.

1. warp loosened by removing wedges or cords.
2. warp shifted over bars to bring unwoven warp strands in front of weaver.
3. wedges replaced to tighten warp strands.

*Economic Gain*

In production:

Two bars furnish taut warp.

Longer web, twice the length between the bars.

Easy shifting of warp to adjust for convenience during wefting.

In product:

Coarse web, but warp and weft strands are more parallel and more evenly spaced.

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# IV

## FRAMELESS TWO-BAR LOOM

### *Distinctive Characteristics*

Weaving implement: a frameless two-bar loom; during weaving one bar is attached to belt passing about weaver's body, the second to a distant post.

Warp devices: two free non-revolving bars (not true beams) over which the warp is wrapped in passing from one to the other.

FIG. 45.—NAVAJO WOMAN WEAVING BELT

This frameless two-bar loom has for the far bar a tree branch and for the near bar a long pole laid across the weaver's lap.

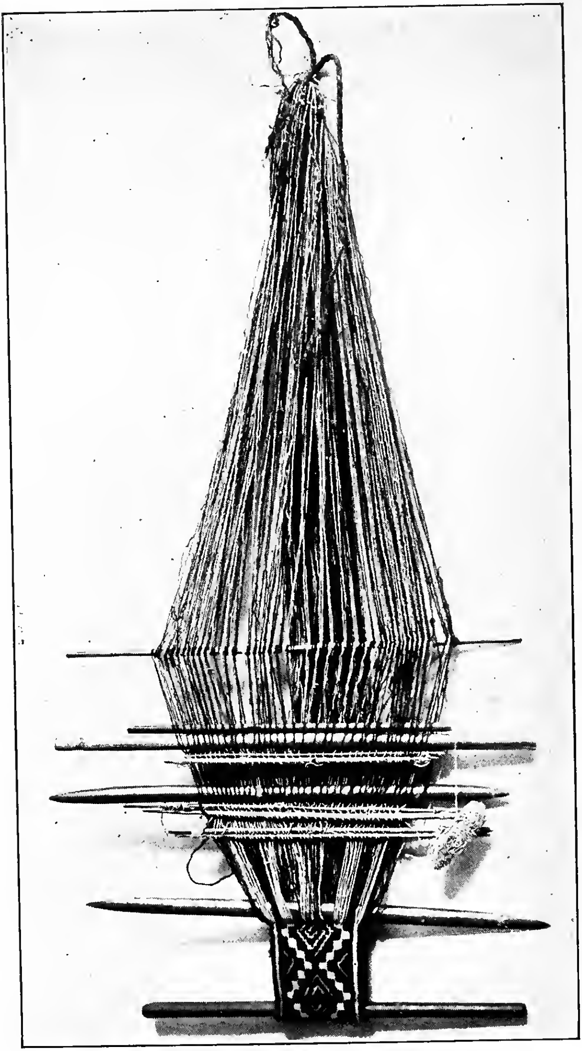


Fig. 46.—Indian Belt Loom, Mexico

Weft devices: a shed-stick, or shed-stick and one or more rod-heddles; a shuttle; a sword-like batten.

Weaving proceeds from below upward, or from front backward.

*Outline*

Example: Mexican belt weaving.

Implement — Frameless two-bar loom (**29**, **29a**).

1. frame.
   none (Navajo Indians to-day quite frequently use a temporary frame of two slanting posts).
2. bars (**19**, **19d**, **20**, **21**, **21a**).
   two light-weight bars (not true beams).
   (1) first attached to some distant object.
   (2) second attached to belt passing about weaver.
3. heddles (**24**, **25**, **26**, **26a**, **b**).
   *a*. none.
   *b*. a shed-rod and one or more rod-heddles.
   *c*. extra short shed-rods.
4. shuttle (**27**, **27a**, **c**, **d**).
   *a*. none.
   *b*. stick-shuttle.
   *c*. bobbin-shuttle.
5. batten (**28**, **28a**, **b**).
   *a*. none.
   *b*. comb.
   *c*. sword-shape blade of wood.

Warping device (**30**, **30b**).
a series of short stakes driven into ground.

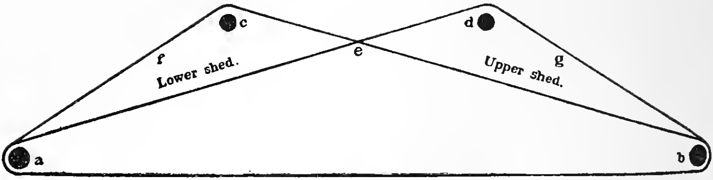
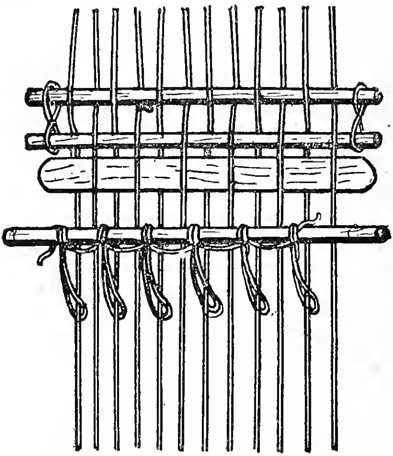



FIG. 47.—WARPING FOR NAVAJO BELT

Warping is done over four stakes. On these the weaver lays her warp as a continuous string in such a way as to secure the shed-lease.

Power — Hand (31).
Process — Loom mounting.



*Reproduced by permission from Harper's "Hand-loom Weaving," Macmillan, U. S. A., and John Hogg, London.*

FIG. 48.—THE SHED-ROD AND ROD-HEDDLE

A flat ruler-shaped shed-rod is entered through alternate warp strands for opening one shed. Below it a rod is laid across the warp and the back strands bound to it by a looped cord for opening the second shed.

Warping.
warp laid about slender stakes to form a lease.
Beaming.
warp placed over free bar at distant post and another attached to weaver's belt, carefully preserving the lease.
Heddling.
1. shed-rod entered through alternate strands for first shed.

2. heddle-rod laid across warp, and a cord caught under the back warp strands and looped over rod for second shed.

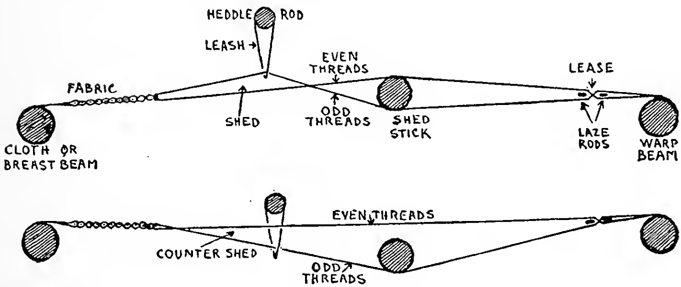



Fig. 49. — Rod-heddle and Shed-rod at Work

Above — The rod-heddle is raised by the hand opening one shed for the weft. Below — The rod-heddle is dropped, opening the second or counter shed for another row of weft.

Wefting.

Shedding, Picking, Battening.

1. shed-rod holds open first shed; batten entered flatwise and turned edgewise in first shed; weft inserted through first shed; batten turned flatwise, beats up first line of weft.
2. rod-heddle lifted to open second shed; batten entered flatwise and turned edgewise in second shed; weft inserted through second shed; batten beats up second line of weft.
3. process is then repeated.

(When pattern is introduced often short shed-sticks mark the pattern.)

Warp adjusting.

1. weaver leans slightly forward to lessen warp tension.

2. warp shifted over bars to bring unwoven portion to weaver.
3. weaver leans back to again tighten tension.

*Economic Gain*

In production:

The distant warp post allows great warp length, and one still twice the distance between bars.

The presence of shedding, picking and battening devices.

In product:

A close and very compact web.

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# V

## TWO-BEAM LOOM

### *Distinctive Characteristics*

Simplest weaving implement for perfectly stretched warp: a loom of two beams with warp extended between them.

Warp devices: the two beams, a cloth beam and a warp beam.

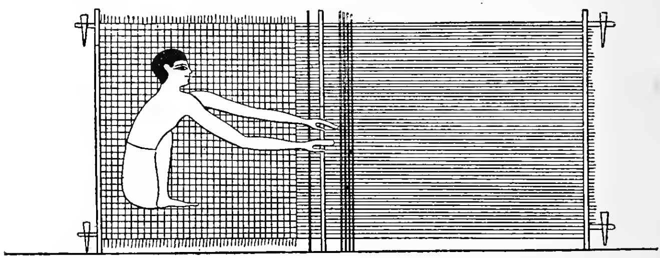

FIG. 50. — EGYPTIAN MAT LOOM

This simple Two-beam loom with stretched warp is pegged to the ground. The weaver is obliged to sit upon the finished web as he works, since the cloth beam does not revolve.

Weft devices: without shedding device, or with shed-stick and one or more rod-heddles; without picking device, or with stick-shuttle of different forms; without battening device, or with sword-shaped batten, or a weaving comb.

Weaving proceeds from front backward, or from below upwards.

*Outline*

Examples: Ancient Egyptian mat makers; Egyptians of Middle Kingdom; Ishogo; Ainu; Navajo; Egyptians of New Kingdom.

Implement — Simple two-beam loom.

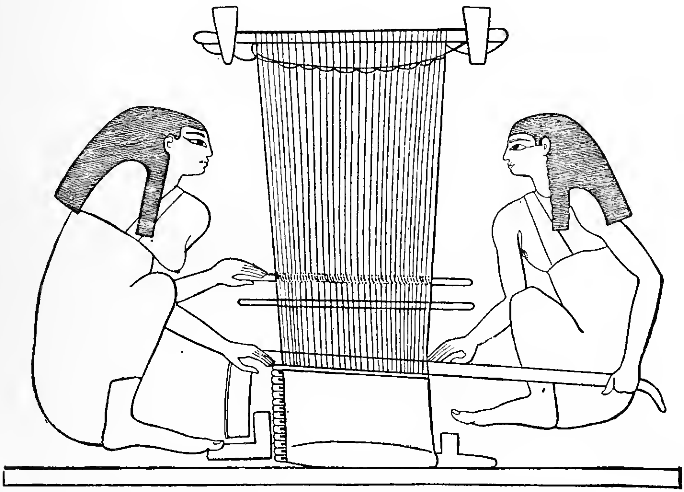

FIG. 51. — EGYPTIAN LINEN LOOM, MIDDLE KINGDOM

A horizontal loom pegged to the ground with shed-rod and rod-heddle and probably two revolving beams.

1. frame (**29**, **29b**, **c**, **d**).
   *a.* none, four pegs secure beams to ground.
   *b.* none, two roof hooks and two floor hooks secure beams.
   *c.* none, warp beam attached to distant post, cloth beam to weaver's belt.

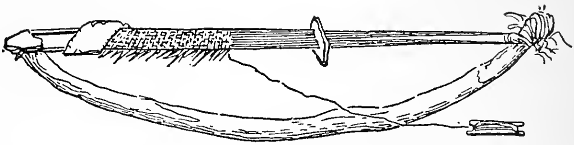

FIG. 52. — SLAVE INDIAN QUILL BELT LOOM

A tree branch bent like a bow furnishes the frame on which to stretch the warp. It is a transitional form, since there are no beams.

*d*. vertical frame of separate parts, two vertical posts, two crossbars.

*e*. vertical frame of complete construction.

2. beams, warp and cloth (**19**, **19e**, **20**, **21**, **22**, **22a**, **23**).

*a*. both beams non-revolving.

*b*. warp beam non-revolving, cloth beam revolving.

*c*. both beams revolving.

3. heddles (**24**, **25**, **26**, **26a**, **b**).

*a*. none, fingers shed.

*b*. shed-stick, and one or more rod-heddles.

4. shuttle (**27**, **27a**, **b**, **c**).

*a*. none, fingers perform the picking.

*b*. long needle-shuttle with hook or eye.

*c*. short stick-shuttle.

5. batten (**28**, **28a**, **b**, **c**).

*a*. none, fingers batten.

*b*. none, save needle-shuttle.

*c*. comb.

*d*. sword-shape blade of wood.

Warping device (**30**, **30b**, **c**, **d**).

*a*. series of stakes.

*b.* wall pegs.
*c.* bobbin creel and reel.

Power — Hand (**31**).


FIG. 53. — NAVAJO METHOD OF WARPING FOR BLANKET MAKING

The diagram shows the ends of two poles and the Navajo method of laying the continuous warp over them to form the shed-lease.

Process — Loom mounting.

Warping.

*a.* none, warp laid directly on beams.
*b.* warp laid over ground stakes.
*c.* warp laid over wall pegs.
*d.* warp strands pulled from spool frame and wound on reel.

Beaming.

*a.* warp laid on beams in place.
*b.* warp arranged on free bars which later act as beams.

Heddling.

*a.* none.
*b.* with rod-heddle and shed-rod.
1. shed-rod entered under and over alternate strands.
2. heddle-rod laid across warp and a cord caught under each back warp strand and looped about heddle-rod.

Wefting.

Shedding, Picking, Battening.

1. shed-rod holds open first shed; batten entered flatwise and turned edgewise in first shed;

weft inserted through first shed; batten beats up first line of weft.

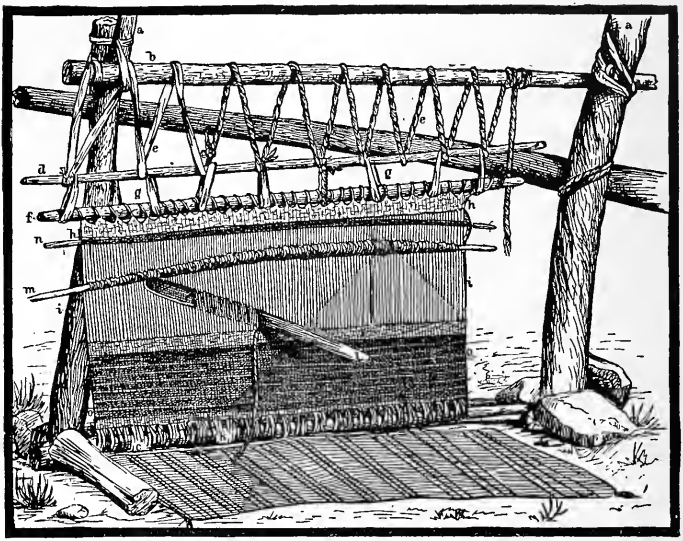


FIG. 54. — NAVAJO LOOM

Shed-rod (*n*), rod-heddle (*m*), batten (*l*), and two non-revolving beams (*f*) are present. The warp beam can be lowered by the cords (*e* and *g*) and the finished web below folded and stitched to the cloth beam.

2. rod-heddle lifted to open second shed; batten entered flatwise and turned edgewise in second shed; weft inserted in second shed; batten beats up second line of weft.
3. process is then repeated.

Warp adjusting.

When there is adjustment the warp beam is lowered, and the cloth beam receives the

woven web either stitched to it in folds or rolled upon it.

*Economic Gain*

In production:

Perfectly stretched warp.

Shedding device increases speed of the more perfect varieties.

Revolving cloth beam increases length of the same.

In product:

Texture firm from tightly and evenly stretched warp, although grades and materials of this type vary greatly.

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FIG. 55. — ZUÑI BELT WEAVER ENTERING WEFT AS BATTEN HOLDS OPEN SHED

FIG. 56. — HOPI BELT WEAVER OPENING UPPER SHED

This simple shaft heddle opens both sheds and does the work of shed-rod and rod-heddle.

Here the heddle is lowered opening upper shed, the batten is entered and turned edgewise to hold open the shed. The shuttle will be passed through shed and batten turned flatwise will beat up weft when it will be removed.

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# VI

## ONE-SHAFT LOOM

### *Distinctive Characteristics*

Weaving implement: a frameless stretched warp loom with shaft-heddle hanging loosely on warp; warp extends between free cloth beam attached to belt passing about body of weaver and distant post.

Warp devices: free cloth beam and bunched warp ends.

Weft devices: one shaft-heddle adjusted by hand; short stick shuttle; sword-shaped batten.

Weaving proceeds from front backward.

### *Outline*

Example: Zuñi and Hopi belt weaving.

Implement — One-shaft loom.

1. no frame (**29**, **29a**).

2. beams (**19**, **20**, **21**, **21a**).
   (1) non-revolving cloth beam attached to weaver's belt, web held over beam by a removable iron pin.
   (2) warp beam.
      *a.* missing; bunched warp attached to distant post.
      *b.* revolving beam held by weaver's feet.
3. one free shaft-heddle of slats holding all warp strands (**24**, **25**, **26**, **26c**).
   (1) eyelets in slats holding alternate warp strands.
   (2) slits between slats for second series of alternate warp strands.
4. stick-shuttle (**27**, **27c**).
5. batten (**28**, **28a**, **c**).
      *a.* fingers only.
      *b.* sword-shaped stick.

Warping device (**30**, **30b**).
a series of short stakes driven into ground.

Power — Hand (**31**).

Process — Loom mounting.

Warping.
warp strands laid in lengths desired without making lease.

Beaming, Heddling.
1. warp ends bunched and attached to post.
2. first series of warp ends passed through heddle eyelets, second series passed through slits.
3. warp ends attached to cloth beam.

Wefting.

Shedding, Picking, Battening.

1. heddle raised to open first shed; batten entered and turned edgewise in first shed; shuttle inserts weft through first shed; batten flatwise beats up first line of weft.
2. heddle lowered to open second shed; batten entered and turned edgewise in second shed; shuttle inserts weft through second shed; batten flatwise beats up second line of weft.
3. process is then repeated.

Warp adjusting.

1. weaver moves in toward warp post.
2. unpins previously finished web and draws over the cloth beam the freshly finished web and again inserts iron pin.

*Economic Gain*

Here the comparison is between the belt looms: the Two-bar loom and the One-shaft loom.

In production:

Increased speed from opening both sheds by same device.

A more easily managed heddle.

In product:

More closely packed weft.

More evenly distributed warp from the shaft heddle.

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53. Primitive heddles.

# VII

## ONE–SHAFT TREADLE LOOM

### *Distinctive Characteristics*

Simplest weaving implement employing foot power: a treadle loom with one suspended shaft-heddle and a shed-rod; crudest attached and permanently entered

batten; the warp beam set in a rough horizontal frame and the free cloth beam attached to a belt about weaver. Developing shedding, battening, frame and power.

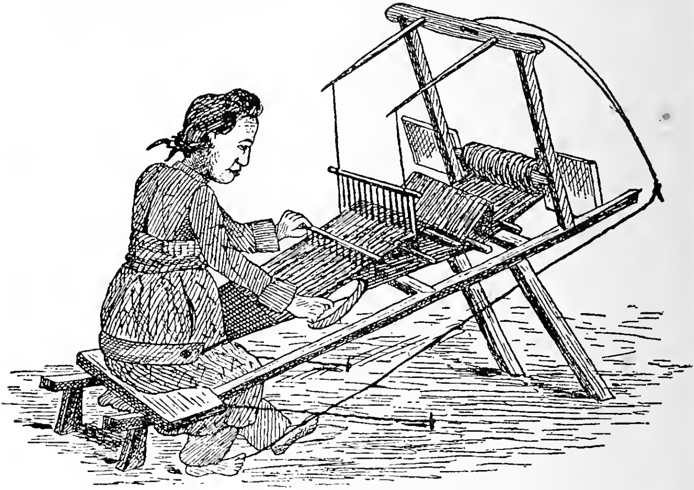

FIG. 58. — EARLY KOREAN LOOM

The one-shaft heddle is crudely lifted by a toe-cord; the shuttle is passed through open shed. When the line of weft is beaten up by the free reed-batten the heddle will be lowered and the shed-rod will open the other shed.

Warp devices: a revolving warp beam and a free revolving cloth beam.

Weft devices: a shed-rod for first shed and a suspended shaft-heddle for second shed; small hollow boat-shaped shuttle inclosing a revolving quill for weft; suspended swinging reed batten.

*Outline*

Examples: Chinese; Japanese; Korean (Ainu, Korean and Indian looms show transitional forms with hand power).

FIG. 57. — EVOLVING HEDDLE-HARNESS, CEYLON

Transitional type: non-revolving beams; shed-rod and shaft-heddle suspended from a crude tripod; weaver's lathe with eye serves as bodkin; free-reed batten.

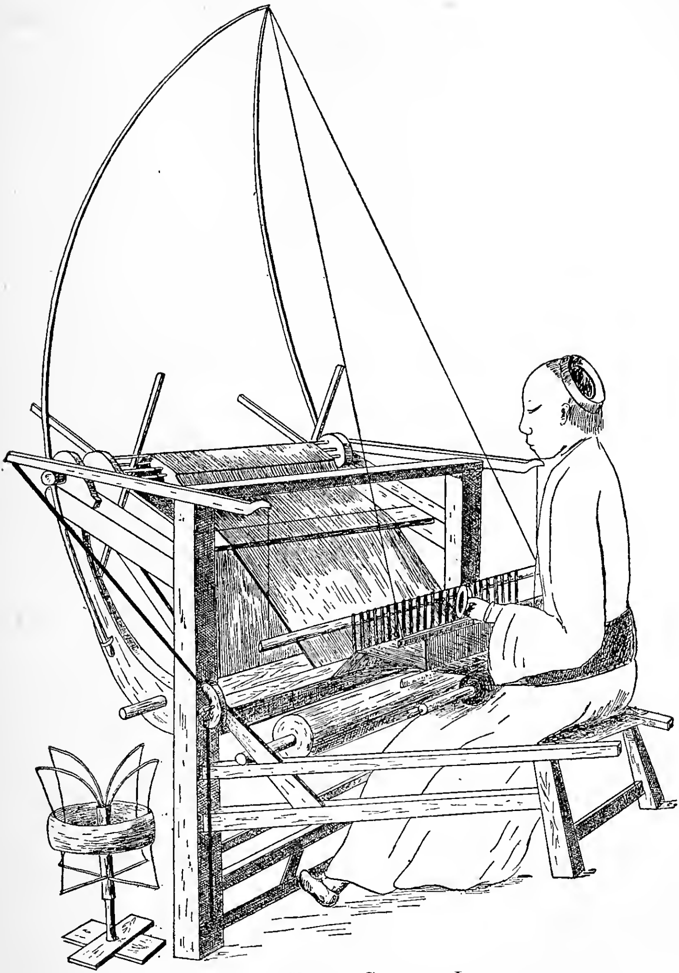

FIG. 59. — EARLY CHINESE LOOM

Another crude attachment for lifting the shaft-heddle is connected with a treadle-slat; reed-batten swung from a unique contrivance.

Implement — One-shaft treadle loom.

1. frame (**29**, **29e**, **f**).
   oblong base with upright posts supporting warp beam, heddle harness and, at times, batten.
2. beams (**19**, **20**, **21**, **22**, **22c**, **d**).
   (1) revolving warp beam attached to frame and governed by
      *a.* stop-boards.
      *b.* stop-pegs.
   (2) revolving cloth beam attached to weaver's belt.
3. heddles (**24**, **25**, **26**, **26d**).
   (1) shed-rod.
      *a.* huge round bar attached to loom.
      *b.* flat bar, free, can be turned edgewise.
   (2) shaft-heddle suspended from frame posts and elevated by foot power with
      *a.* cord loop over toe.
      *b.* treadle board.
      *c.* swinging slat-board.
4. shuttle (**27**, **27b**, **c**, **d**).
   *a.* needle-shuttle.
   *b.* stick-shuttle.
   *c.* bobbin shuttle.
5. batten (**28**, **28d**, **e**).
   *a.* free reed batten.
   *b.* swinging reed batten.

Warping device, probably stakes (**30**, **30b**).

Power — Hand for picking and battening (**31**, **31a**).
Foot for moving shaft-heddle.

Process — Loom mounting.

Warping as in Two-shaft treadle loom.

Heddling.

1. one series of alternate warp strands passed over shed-rod.
2. second series of alternate warp strands passed under shed-rod, then between slats of the one heddle-shaft.

Wefting.

Shedding, Picking, Battening.

1. shed-rod holds open first shed; shuttle inserts weft through first shed; already entered batten beats up first line of weft.
2. shaft-heddle raised by treadle holds open second shed; shuttle inserts weft through second shed; batten beats up second line of weft.
3. process is then repeated.

Warp adjusting.

1. fresh warp unrolled from warp beam.
2. finished web wound on free cloth beam attached to weaver's belt.

### *Economic Gain*

Comparison here is with the Two-beam loom, the last wide cloth type.

In production:

Introduction of foot power for the one heddle.

A permanently entered batten.

Revolving warp and cloth beams.

In product:

A longer web.

A closer, more even web of fine yarn.

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Ephriam, fig. 43. Loom of Japan.

44. Loom of Korea.

45. Loom of China.

Magazines. See Magazine Illustration.

# VIII

## TWO-SHAFT TREADLE LOOM

### *Distinctive Characteristics*

Weaving implement: a two-shaft treadle loom; beams outside of loom frame; cloth beam pegged to ground, or attached to posts, or to belt of weaver; without warp beam, or when with it fastened to distant post, to roof, or high on side wall. Developing beams and frame.

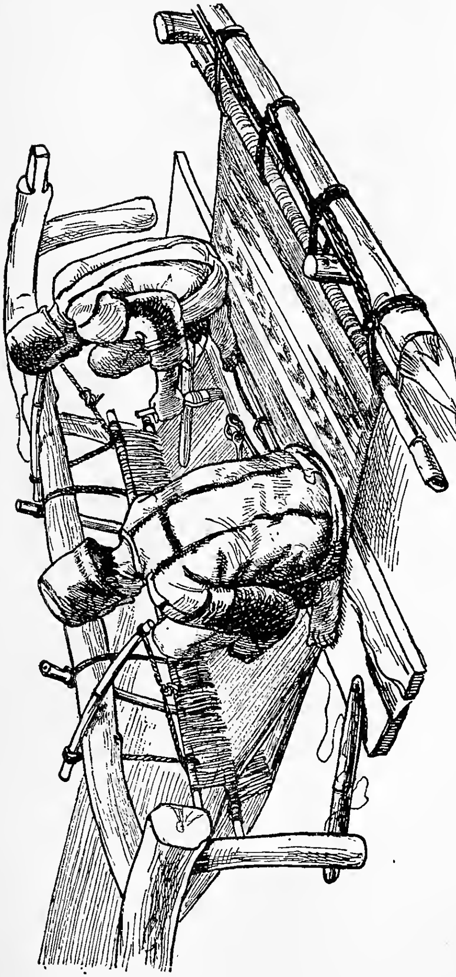

Fig. 60. — Another Crude Loom from India

Non-revolving beams; heddle-harness balanced over strong cross-bar; treadles absent; comb and sword-batten; stick shuttle.

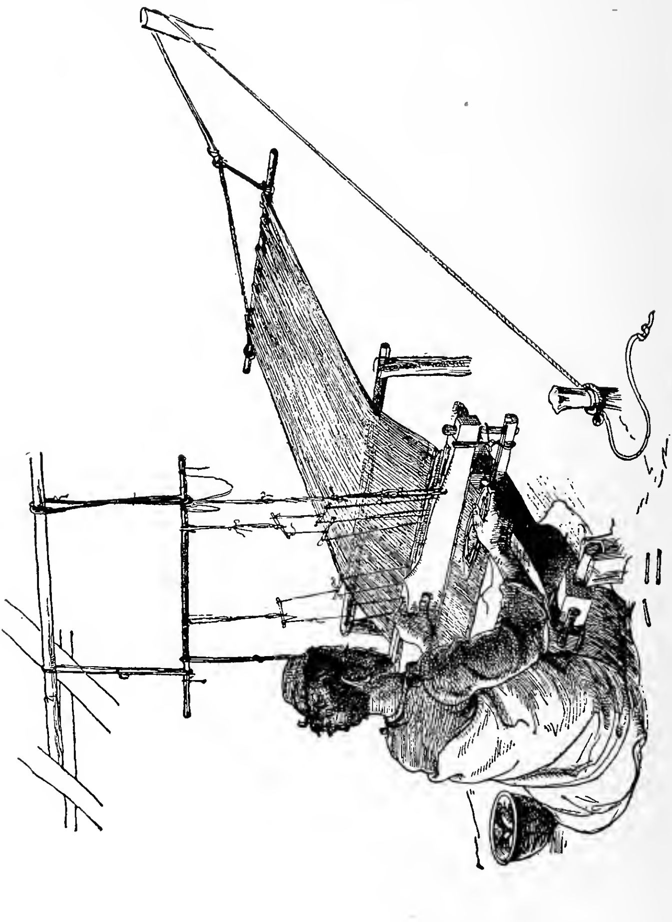

FIG. 61. — OUTDOOR LOOM OF THE HILLS, INDIA

Revolving cloth beam; more perfect harness worked by treadles; suspended reed; bobbin shuttle.

Warp devices: non-revolving, or revolving cloth beam; non-revolving warp beam, or bunched warp ends with cord attachment.

Weft devices: two or more shaft-heddles worked by treadle cords; stick-shuttle, or short boat-shaped shuttle with inner bobbin; for battening, the stick-batten, or a suspended reed batten.

*Outline*

Examples: India outdoor, and simpler indoor weaving; W. African coast; Medieval Egypt.

Implement — Two-shaft treadle loom.

1. frame (**29**, **29e**, **g**).
   *a.* none, branch of overhead tree supports heddle and batten.
   *b.* two trees, or two high posts, between which is a crossbar for suspending heddle and batten.
   *c.* four-post, or tripod frame.
2. beams, free from frame (**19**, **20**, **21**, **21b**, **22**, **23**).
   (1) cloth beam.
      *a.* revolving, pegged to ground.
      *b.* revolving, fastened to weaver's belt.
      *c.* non-revolving, fastened to post.
   (2) warp beam, non-revolving.
      *a.* none, warp ends bunched, attached to post.
      *b.* beam attached to distant post.
      *c.* beam fastened to ceiling, or high on side wall.

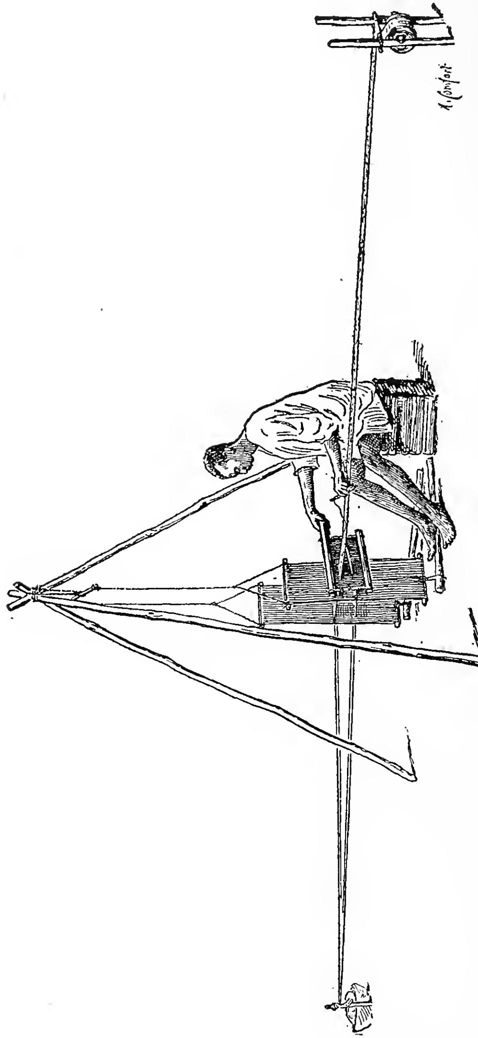

Fig. 62. — West African Weaver at Crude Two-shaft Treadle Loom

No revolving beams cause him to shift along the tripod of poles which support the heddle harness. The batten hangs freely on the warp as in Fig. 58.

3. heddles, two shaft-heddles suspended by cord gear which connects with foot power in pit below ground (**24**, **25**, **26e**).
   *a.* treadle cord loops.
   *b.* inverted halves of cocoanut shell, or bits of bamboo sticks.
   *c.* long wooden treadles.
4. shuttle (**27**, **27c**, **d**).
   *a.* stick-shuttle.
   *b.* boat-shape shuttle with weft bobbin.
5. batten (**28**, **28b**, **d**, **f**).
   *a.* stick-batten; comb.
   *b.* suspended reed-batten.

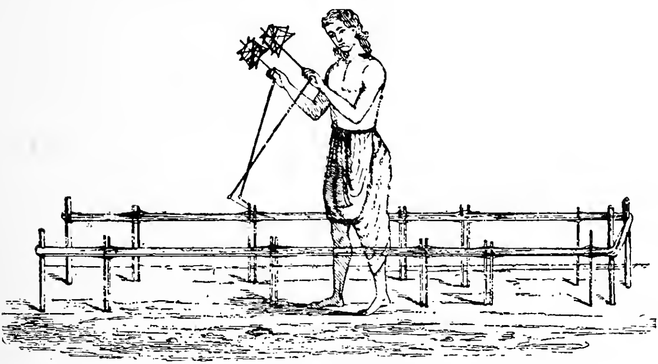

FIG. 63. — STAKE WARPING, INDIA

Two warps are laid at one time.

Warping device (**30**, **30b**, **c**).
   *a.* row of stakes set in pairs.
   *b.* warping frame.

Power — Hand and Foot (**31**, **31a**).

Process — Loom mounting.

Warping, warp interlaced through and around parallel row of stakes, or pegs, and so crossed as to form the leases.

Beaming, Heddling.

1. warp attached to one beam.
2. one series of alternate warp strands entered through eyelets of one heddle-shaft, and second series through eyelets of second shaft.
3. warp attached to second beam.

Wefting.

Shedding, Picking, Battening.

1. first treadle lowers first heddle, opening first shed; shuttle inserts weft in first shed; batten beats up first line of weft.
2. second treadle lowers second heddle, opening second shed; shuttle inserts weft in second shed; batten beats up second line of weft.
3. process repeated.

Warp adjusting.

1. warp let in from distant post.
2. finished web wound on cloth beam.

*Economic Gain*

In production:

Foot power for both heddles.

Unified shedding device, with both sheds opened by a like device.

The suspended reed batten of firmer, stronger construction.

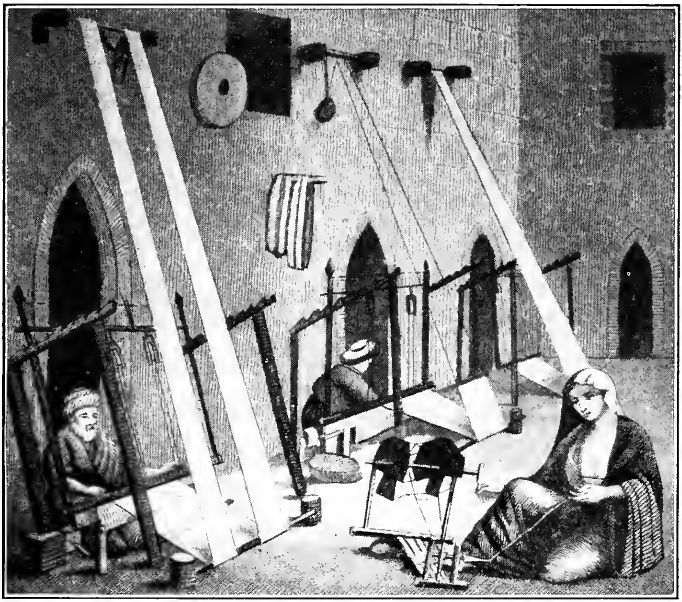

Fig. 64. — Egyptian Loom, Middle Ages

Revolving cloth beam, warp extended to side wall.

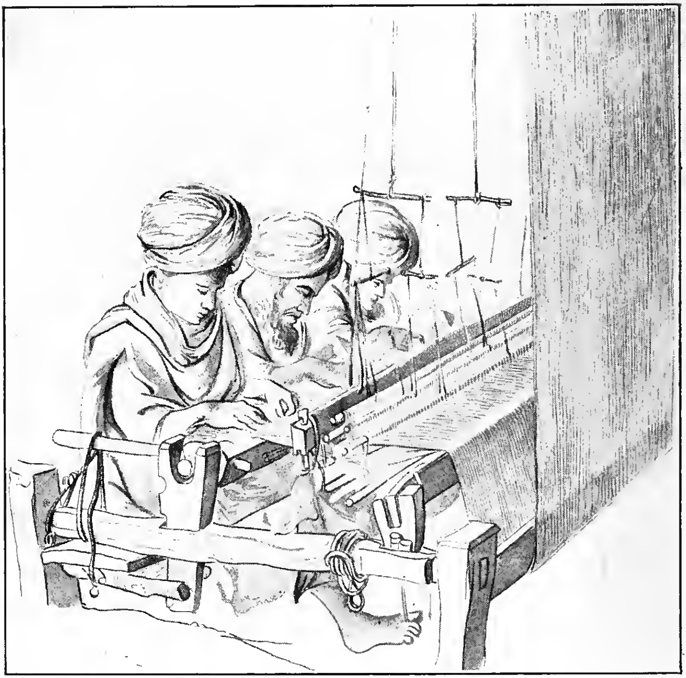

FIG. 65. — A SHAWL LOOM, ASIA

Revolving cloth beam, warp extended upward to ceiling.

In product:

A close and even web, although fabrics from this type are of many grades and materials.

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# IX

## PERFECTED HAND LOOM

### *Distinctive Characteristics*

First weaving-implement with its entire mechanism united within the frame and working in unison: a two or more shaft treadle loom with its two beams set in ends of frame.

Warp devices: revolving warp and cloth beams.

Weft devices: two or more shaft heddles worked by treadles; bobbin-shuttle, fly-shuttle or drop-box-shuttle; stick-batten, or suspended reed-batten.

### *Outline*

Examples: Medieval Greek; Colonial; French (two weavers); English fly-shuttle looms.

Implement — Perfected hand loom.

1. frame including all working parts (**29**, **29e**, **h**).

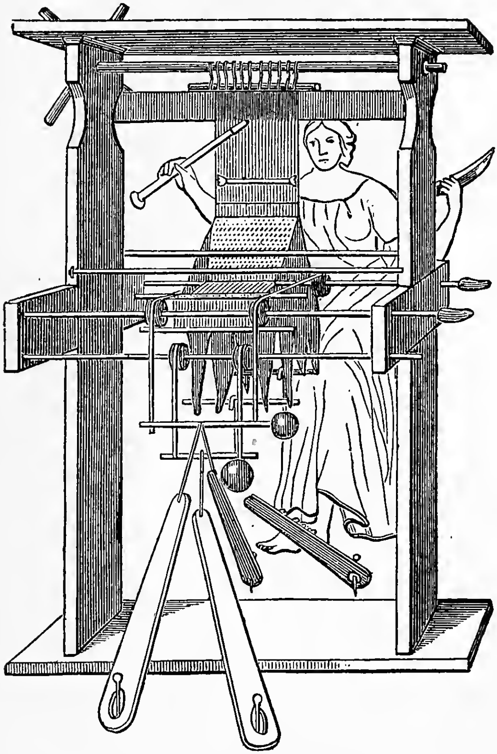

FIG. 66.—GREEK LOOM OF MIDDLE AGES

An early Perfected hand loom with all parts united within the frame. It differs from the later form in its vertical warp and horizontal heddles.

*a*. two cross-shape side boards joined above and below.

*b*. four posts joined by bars at sides and ends.

2. cylindrical revolving beams, warp and cloth (**19, 20, 21, 21c, 22, 22d**).
   *a.* with vertical warp.
   *b.* with horizontal warp.

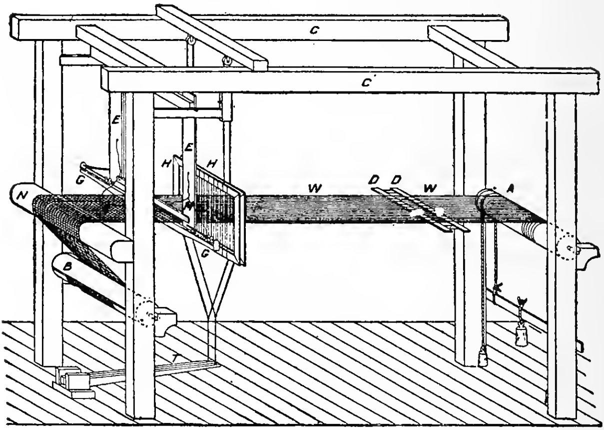


FIG. 67.—PERFECTED HAND LOOM WITH FLY-SHUTTLE

A rectangular frame supports all working parts. Horizontal warp, *W*, extends between the revolving warp beam, *A*, and the cloth beam, *B*; two treadles, *T*, raise and lower alternately the two shaft heddles, *H*, to open the warp sheds. The swinging batten, *E*, beats home the weft; while at its two ends the shuttle-boxes, *G*, receive the shuttle as it is thrown from box to box by a jerk of the black peg attached to a string loop.

3. heddles, two or more shaft-heddles constructed with thread eyelets stretched between two laths (**24, 25, 26e**).
   *a.* horizontal heddles.
   *b.* vertical heddles balanced by cords over pulleys and attached below to treadles.

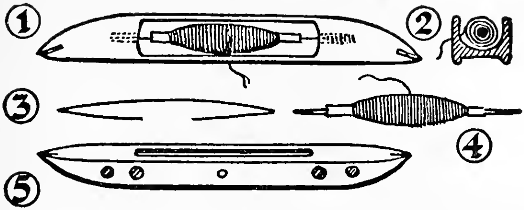


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FIG. 68.— HAND SHUTTLE

*1*, Boat-shaped shell and inside bobbin. *2*, Section of shell and bobbin. *3*, Spring for holding quill. *4*, Bobbin, a quill with yarn wound on. *5*, Side of shuttle showing center eye where yarn escapes from the shuttle.

4. treadles.
   *a.* worked by balance weights.
   *b.* worked by direct treading process.

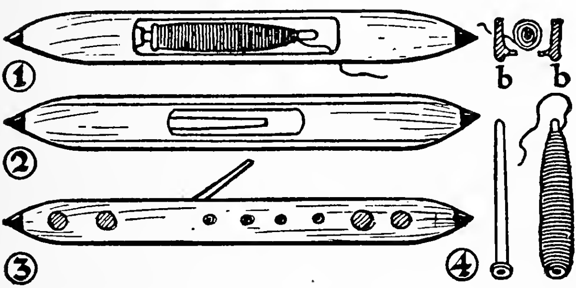


FIG. 69.— FLY-SHUTTLE

A longer, deeper, broader, heavier shuttle.

5. shuttle, revolving bobbin within boat-shape hollow box (**27**, **27d**, **e**, **f**).
   *a.* hand bobbin-shuttle.
   *b.* fly-shuttle with wheels upon which to travel and a shuttle-race with end boxes.

*c.* drop-box shuttle with tiers of end boxes which rise and fall to bring compartments to shuttle-race level.

6. batten (**28**, **28d**, **f**, **h**).
   *a.* free stick batten.
   *b.* reed-batten set in pendulous frame, or lathe.

Warping device (**30**, **30c**, **d**).
*a.* warping board or frame with pegs.
*b.* warping mill, reel and bobbin frame.

Power — Hand and Foot (**31**, **31a**).

Process — Loom mounting.

Warping, warp threads measured off in equal lengths and crossed to form the two leases on warping frame or mill.

Beaming, Heddling.

1. warp ends spread across warp beam and strands wound on, carefully preserving leases.
2. ends of alternate strands entered through eyes of first heddle, ends of second set of alternate strands entered through eyes of second heddle to prepare for shedding.
3. ends of all strands entered in regular order through reed-batten.
4. ends attached to cloth beam, stretching warp between two beams.

Wefting.

Shedding, Picking, Battening.

1. foot presses down first treadle which draws down first heddle with the first series of alternate warp strands threaded through it, and simul-

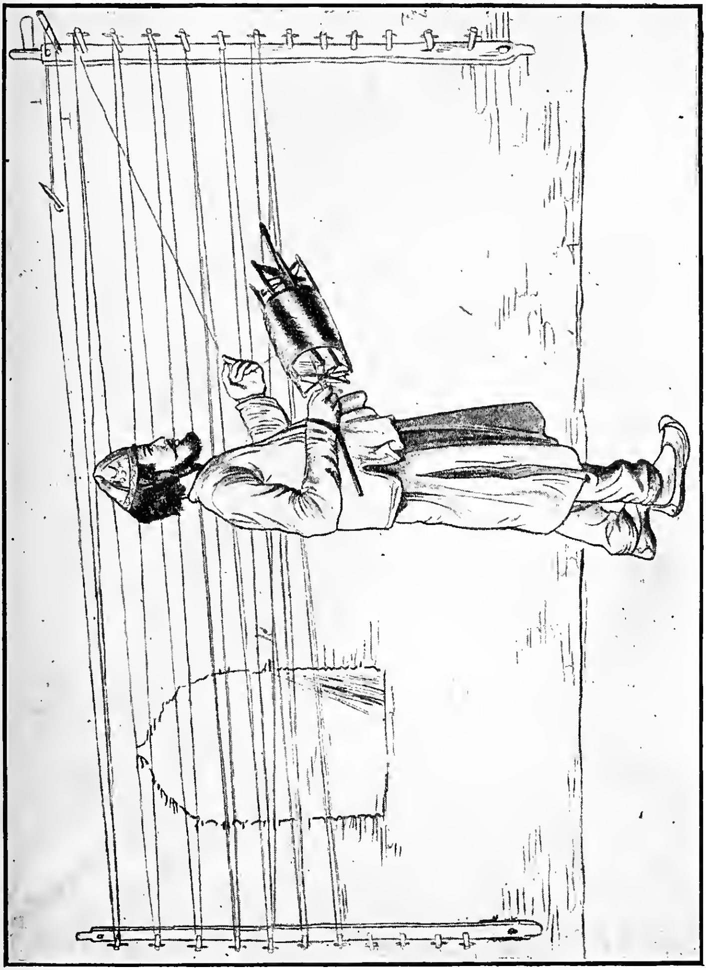

FIG. 70.—PEG WARPING, INDIA
This method is more usual in Europe.

FIG. 71.—HUNGARIAN PEASANT WARPING

This warping reel similar in form to the mill is turned by the left hand as the right lays on two strands at a time.

taneously raises second heddle with the second series of alternate strands threaded through it, thus opening the first shed. (Simpler method, p. 164.)

2. hand shuttle thrown by hand through open shed; fly-shuttle and drop-box-shuttle driven, by a quick jerk given the picking device, along the shuttle-race through the open shed; in each instance the shuttle leaves behind a line of weft between the divided warp.

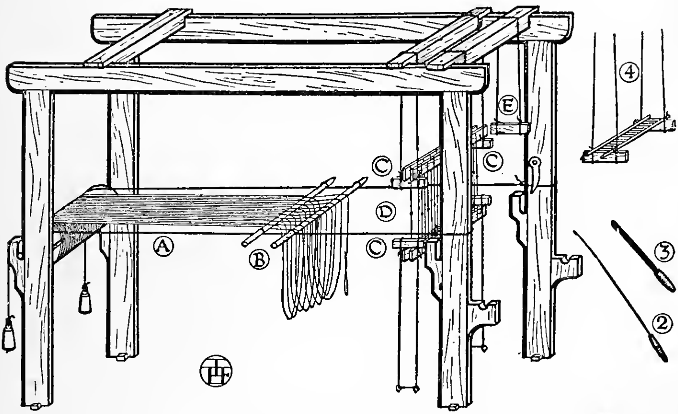


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FIG. 72.—LOOM PREPARED FOR ENTERING WARP THROUGH HEDDLES AND REED-BATTEN

Entering need only be done when a harness is new; after the first entering the new warp strands are tied to old strands of the previous web left long enough to still pass through the heddles and reed. For entering, the warp coiled on the beam is gently unwound, preserving the two leases by the rods, *B*. Then the slender hook, *2*, draws each strand through the heddle eyelets, *D*, and the flat hook, *3*, between the dents of the reed, *4*.

3. stick-batten is run into shed to beat up weft, or lathe reed-batten is forcefully swung against the line of weft just put in.
4. depression of the second treadle reverses the order of heddles opening the second shed, and

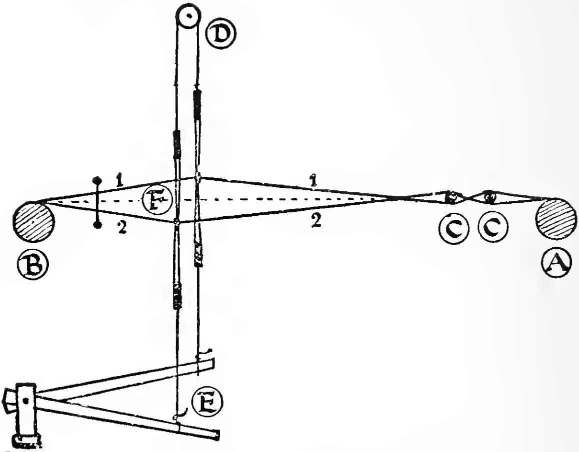


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FIG. 73.—SHED OPENING MECHANISM. TREADLES AND HEDDLES AT WORK

*A*, warp beam; *B*, cloth beam; *C*, lease rods; *D*, heddle harness pulley; *E*, treadles; *F*, shed opened by heddles and treadles.

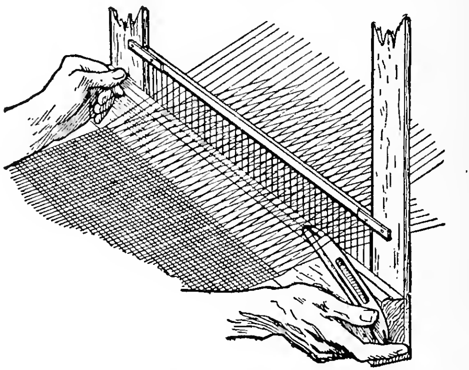

FIG. 74.—HAND-SHUTTLE AT WORK

The shuttle is thrown from one hand to the other, leaving a line of weft through the open shed when the reed-batten will beat close the line of weft.

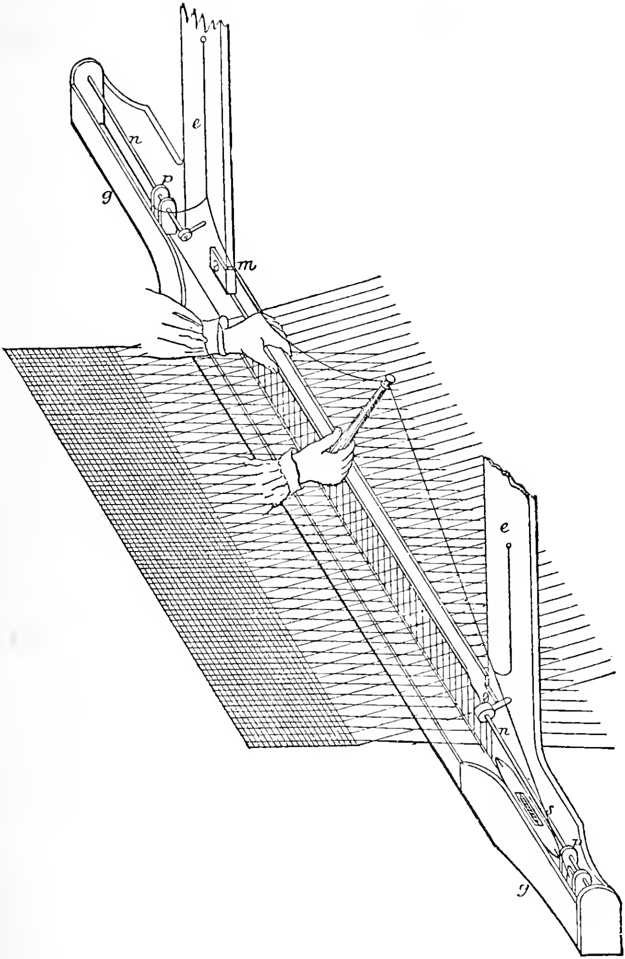


FIG. 75. — FLY-SHUTTLE AT WORK

With each jerk of the peg in the right hand the shuttle flies through the open shed to the shuttle box at the other end, leaving in its trail a line of weft. Then the left hand, freed from helping as required by the hand-shuttle, beats up the weft with the reed-batten.

at the same time if the drop-box-shuttle is in use, drops or raises the end boxes so that the shuttle desired is on a level with shuttle-race.

5. shuttle deposits another line of weft.
6. batten beats up second line of weft.
7. process is then repeated.

Adjustment of warp when some distance of web is woven: wefting is stopped and fresh warp is "let off" from warp beam and woven web "taken up" on cloth beam.

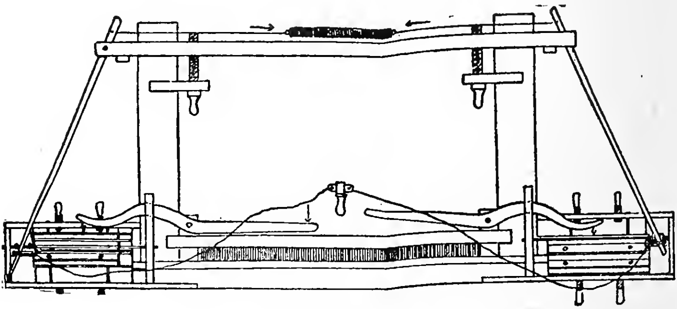

Fig. 76.—Drop-box Fly-shuttle

The shuttle here works as in Fig. 75, but there are added for shuttles of different colored yarns two tiers of end boxes with a contrivance for raising and lowering the boxes to bring them level with the warp shed as each color is needed.

*Economic Gain*

In production:

Developed frame unites loom mechanism.

Steadier beams.

Longer web on revolving beams with "take up" and "let off" motions.

In later varieties with fly-shuttle, a wider web and greater speed.

In product:

More uniform texture from smooth running mechanism.

More parallel warp from perfectly stretched warp.

More even weft from refined shedding, picking and battening devices.

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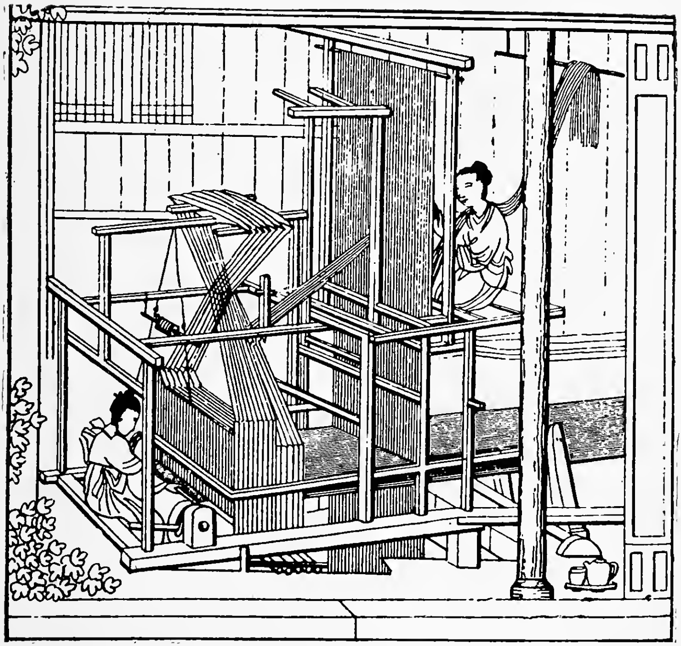

FIG. 77.—CHINESE DRAW LOOM

The warp strands stretch from the cloth beam through the swinging reed-batten; through the first heddle harness worked by treadles; then through the free leashes worked by the drawboy above; when they pass to the warp beam beyond the picture at the right.

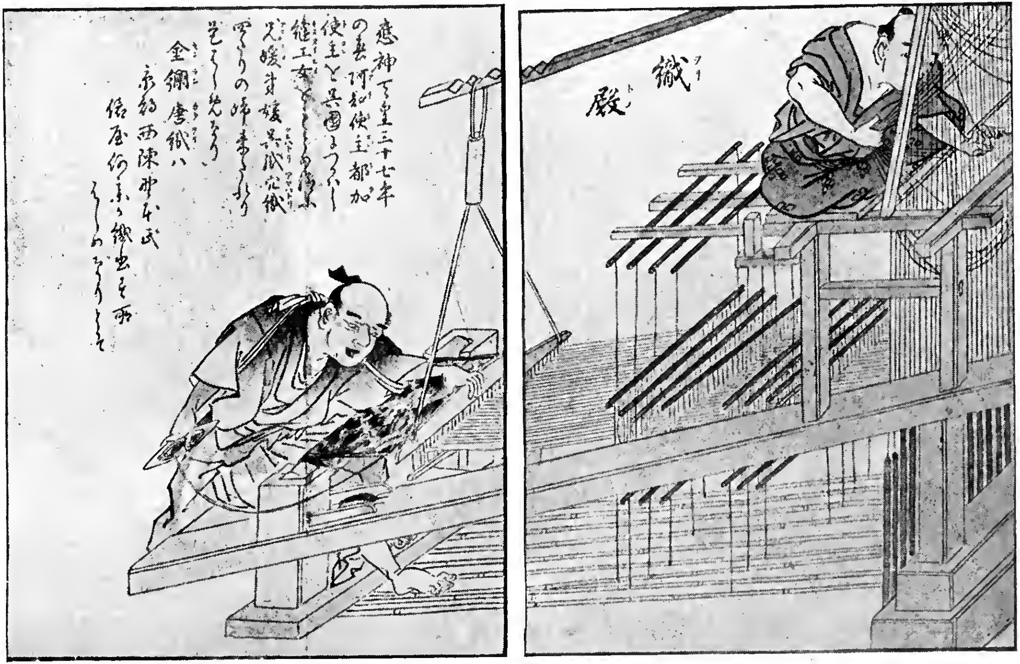


FIG. 78.—JAPANESE WEAVER BEATING-UP WEFT AND THROWING SHUTTLE

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# X

## DRAW LOOM

### *Distinctive Characteristics*

First mechanism for elaborate figured weaving: one operating a compound system of shedding on the same warp strands; the system applied to the Perfected hand loom.

Weft device for shedding: two separate shedding systems with distinct functions — a shaft mounting worked by treadles for forming the pattern edges; and a drawboy mounting or harness with tails and simples

worked by the drawboy for forming the texture of the web.

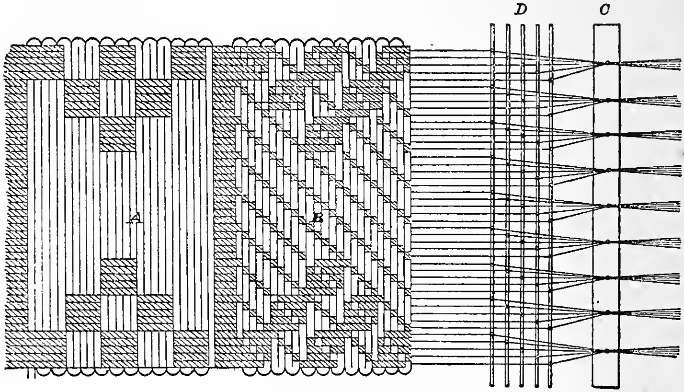


FIG. 79.—DIAGRAM SHOWING ACTION OF TWO HARNESS SYSTEMS

*A*, Work accomplished by first harness which outlines on a large scale the pattern. *B*, Work accomplished by second harness which breaks up this pattern in detail.

### *Outline*

Examples: Chinese draw loom; French draw loom.

Implement — Draw loom.

1. frame (**29**, **29e**, **i**).
2. beams (**19**, **20**, **21c**, **22**, **22d**). } Similar to the
4. shuttle (**27**, **27d**, **e**). } Perfected
5. batten (**28d**, **28f**). } hand loom.
3. shedding mechanism (**24**, **26e**, **f**).
   (1) front harness of shaft heddles with long eyes.
   (2) back harness of free heddling strings (managed by assistant).
   leashes with lingoes, hangers, mails, sleepers.

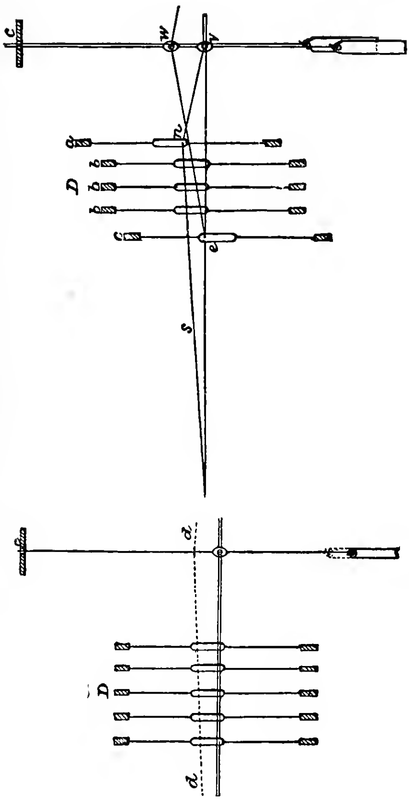


FIG. 80.—TWO SYSTEMS OF HARNESS

The warp strands pass through the long eyelets of the shaft harness, *D*, then on through the round eyelets of the free leashes, *C*. The long eyelets of the first system of heddles permit action on the second system of heddles.

comber board (hole board).
necking cords.
pulley box.
tail cords.
simple cords on which pattern is tied up.

Power — Hand and Foot, weaver (**31**, **31a**, **b**).
Hand, drawboy assistant.
Process — Loom mounting.
Warping, Beaming similar to the Perfected hand loom.
Heddling, warp strands entered through both shedding systems: the shaft-heddles and the free heddling strings.
Wefting.
Shedding.
1. weaver with treadles operates shaft-heddles for outlining pattern.
2. drawboy adjusts string-heddles for web texture.
Picking, Battening, as on Perfected hand loom.

### *Economic Gain*

Comparison here is with the many-shaft loom of the previous type used in elaborate pattern weaving.
In production:
Less floor space needed for free leashes.
A loss in production because of more elaborate fabric.
In product:
Elaborate pattern of fine texture.

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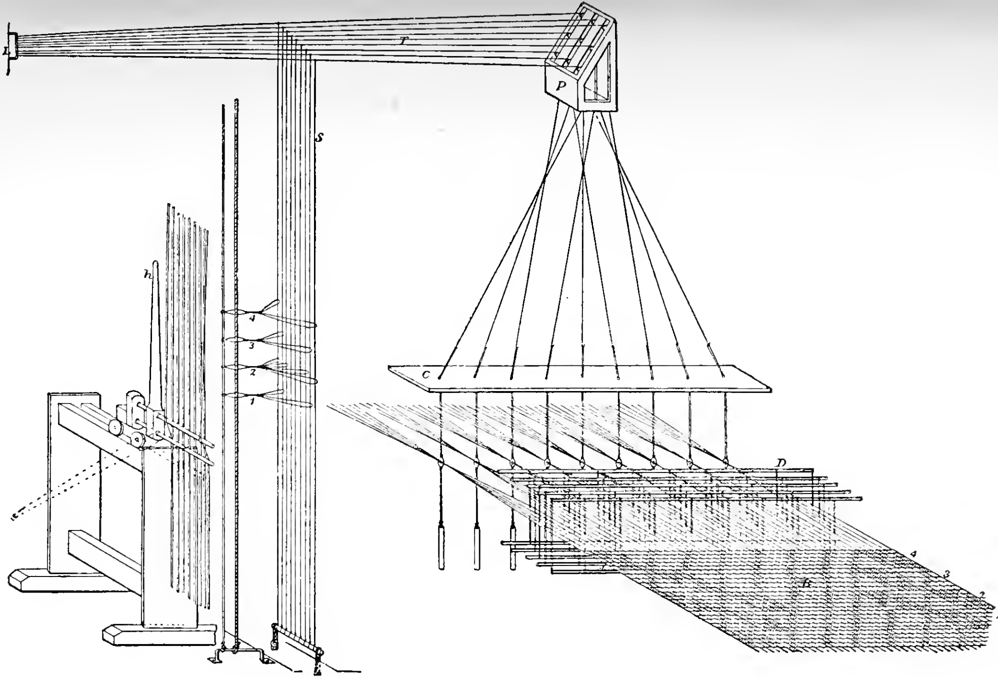


Fig. 81.—Diagram of European Draw Loom

The leashes pass up through comber board ($C$); turning at pulley box ($P$) the cords or tails of harness (T) extend horizontally. From these drop vertical cords, or the simple, on which the pattern is arranged by means of loops *1, 2, 3, 4*. When elaborate patterns are worked the drawboy or weaver's assistant requires the mechanical fork (left) to pull down the cords which raise the leashes.

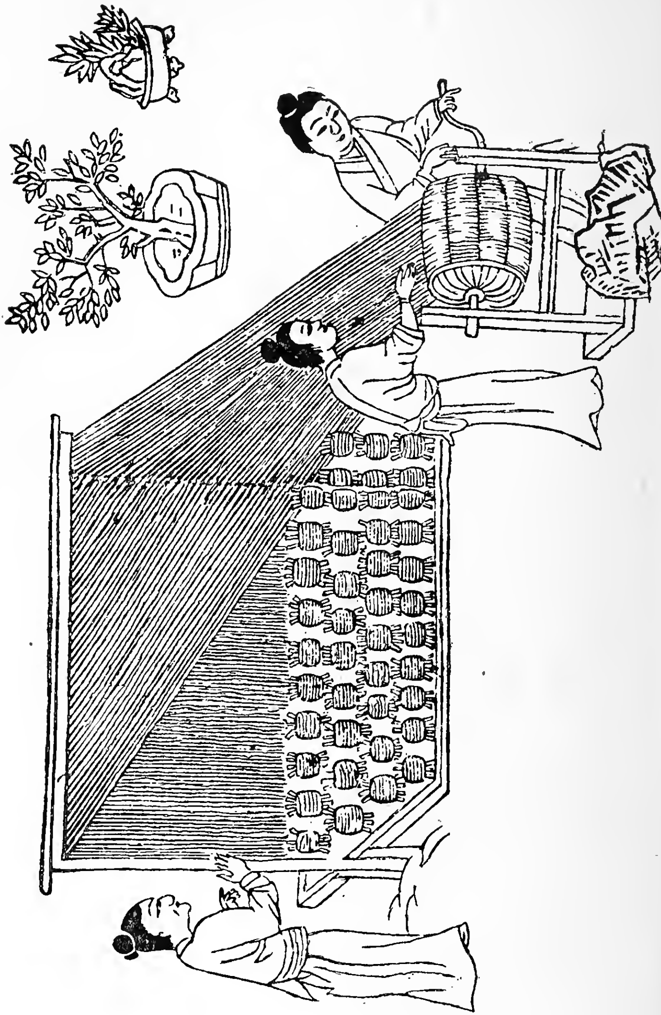

Fig. 82.—Silk Warping in Ancient China.

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# XI

## JACQUARD HAND LOOM

### *Distinctive Characteristics*

The most universally employed mechanism for elaborate pattern making: a shedding attachment which simplifies the complex mechanism of the Draw loom with

its extensive tie-up and drawboy; it was first adjusted to the hand loom and later to the power loom.

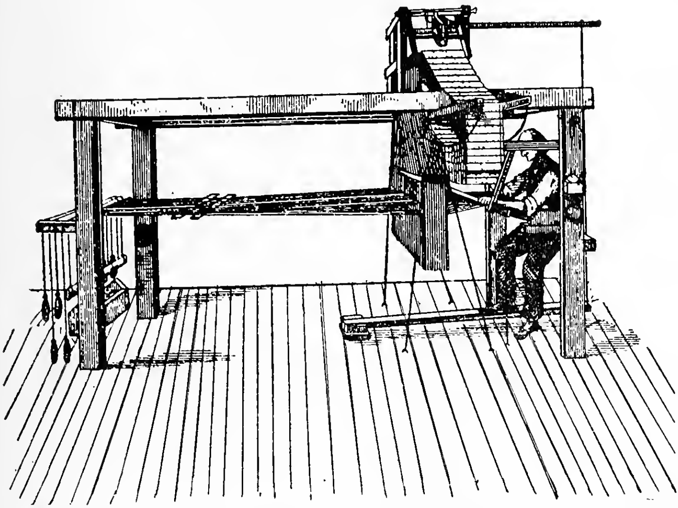

FIG. 83.—JACQUARD HAND LOOM, 1804

A hand loom mounted with a hook and needle harness worked by an endless band of pattern cards for elaborate pattern weaving.

Weft device for shedding: an endless band of pattern cards worked with a hook and needle harness.

*Outline*

Example: Jacquard hand loom.

Implement—Jacquard mechanism attached to hand loom.

1. frame (**29**, **29e**, **i**).
2. beams (**19**, **20**, **21**, **21c**, **22**, **22d**). } Similar to Perfected hand loom.
4. shuttle (**27**, **27d**, **e**, **f**).
5. batten (**28**, **28d**, **f**).

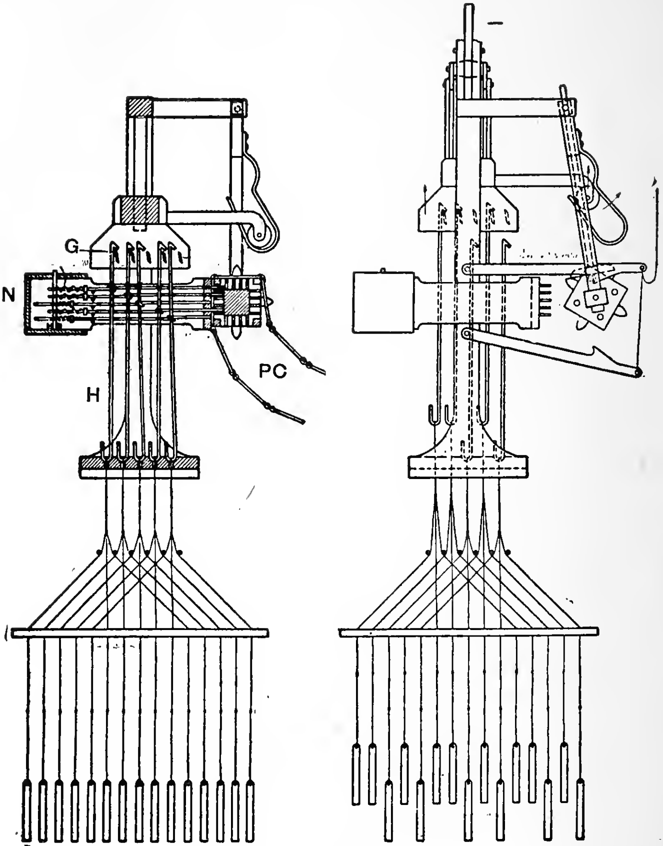


FIG. 84.—JACQUARD MECHANISM

A series of vertical hooks (*H*) connect with the heddles of the loom. These are raised according to a pattern punctured on pattern cards (*PC*) by a series of horizontal needles (*N*) attached to them at their points of crossing. When the pattern cards press back certain horizontal needles they carry the hooks with them beyond the griff (*G*). This allows the griff to rise and carry up the remaining hooks which raise the heddles.

3. shedding apparatus placed on top of loom to take the place of the drawboy and pulley-box (**24**, **26e**, **f**, **g**).
   (1) shaft-heddles.
   (2) string-heddles.
   endless chain of perforated pattern cards.
   revolving prism or cylinder which swings.
   series of horizontal needles with eyelets.
   needle board.
   series of vertical hooks passing through needles and controlled by them.
   bottom board.
   griff.
   necking cords.

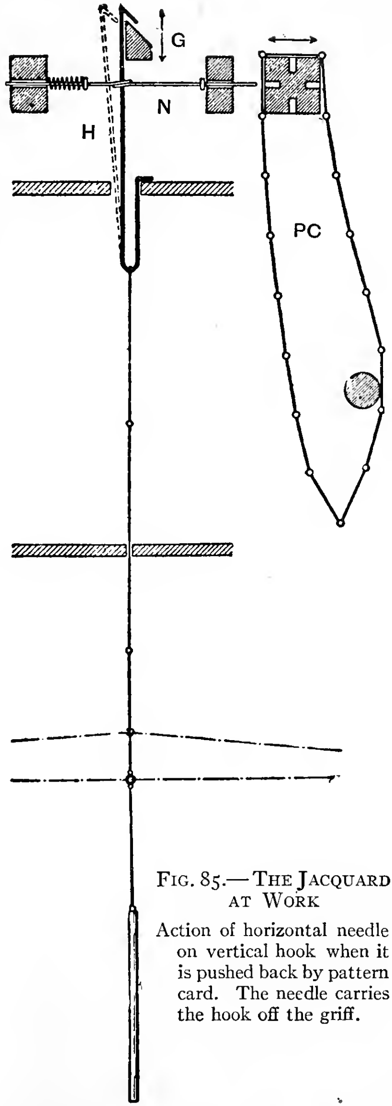


FIG. 85.—THE JACQUARD AT WORK

Action of horizontal needle on vertical hook when it is pushed back by pattern card. The needle carries the hook off the griff.

leash, or leash strings with mails and lingoes.
comber board.

Power — Hand and Foot (**31**, **31a**).

Process — Shedding.

1. pattern card passed over cylinder and pressed against needles.
2. blank spaces on cards push back certain needles, giving attached hooks an inclination.
3. griff rises, carrying up hooks remaining vertical.
4. rising hooks carry up leash cord with warp strand it controls.
5. cylinder bearing pattern card moves away and turns one fourth revolution, while springs return needles to normal position.

*Economic Gain*

In production:

Less time for simpler " tie-up " of shedding mechanism.
More rapid weaving possible.
Less floor space needed.
One worker instead of two.

In product:

Still more elaborate pattern.
Greater width of web.

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# XII

## PLAIN POWER LOOM

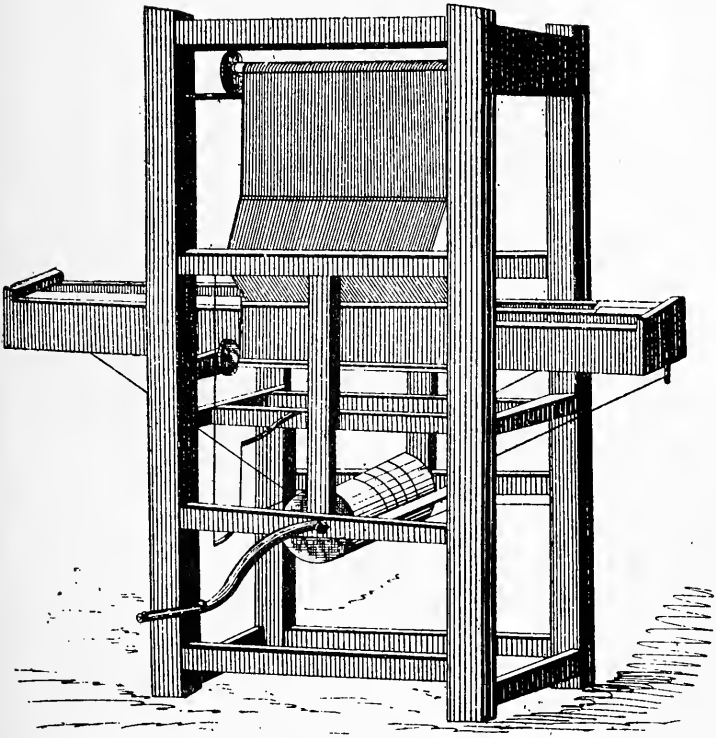

FIG. 86.—CARTWRIGHT'S FIRST POWER LOOM, 1785

A loom with vertical warp. The web wound gradually as it was woven. The shuttle was propelled mechanically through the long trough-shaped form extending out at the sides.

### *Distinctive Characteristics*

First weaving machine: a loom run by power and so adjusted that beams, heddles, shuttles and batten work automatically and in unison.

Warp devices: cloth and warp beams that automatically "take on" cloth and "let off" warp.

Weft devices: shaft-heddles that automatically open sheds; shuttles that automatically insert weft and a reed-batten that automatically beats up weft.

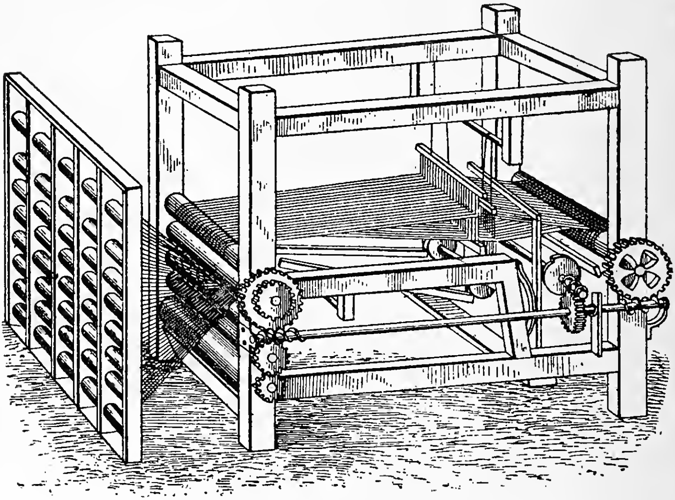

FIG. 87.—CARTWRIGHT'S SECOND POWER LOOM, 1786

A frame of yarn bobbins served in place of a warp beam. The lathe or slay is reversed to oscillate from below.

*Outline*

Example: Roberts' power loom.

Implement — power loom.

1. frame, solid square structure of iron (**29**, **29e**, **i**).
2. beams.
   (1) warp beam with pulley, cord and weight attachment for automatic "let off" (**19**, **20**, **21**, **21c**, **22**, **22d**, **e**).

(2) warp roller.
(3) cloth beam with toothed wheel, pinion and ratchet wheel for automatic "take on."
(4) breast beam.

3. heddle-shafts suspended from pulleys and worked from below by tappets and levers. (Other looms may use dobbie) (**24**, **25**, **26e**).

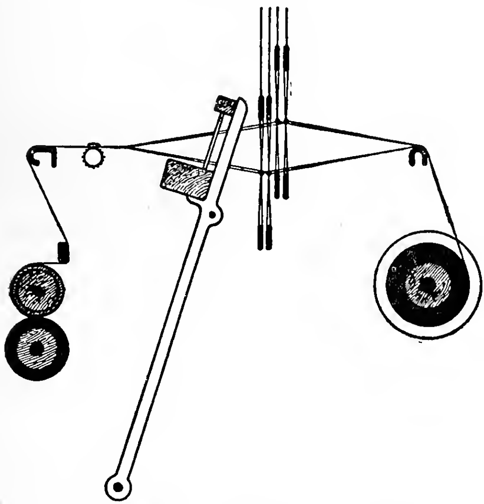

FIG. 88.—WORKING PARTS OF POWER LOOM

Left, cloth beam, breast beam. Center, reed-batten oscillating from below; four shaft-heddles two down two up opening shed. Right, warp beam.

4. bobbin-shuttle thrown by levers (**27**, **27d**, **e**, **f**).
5. batten with shuttle-race, shuttle-boxes and pickers is swung from below (**28**, **28d**, **g**).
6. driving gear.
7. stop motion devices.

Power — Steam (**31**, **31c**).
Process — Loom mounting (**30**, **30e**).
Warping, Beaming — by mill and frame.
Heddling — warp entered by hand.

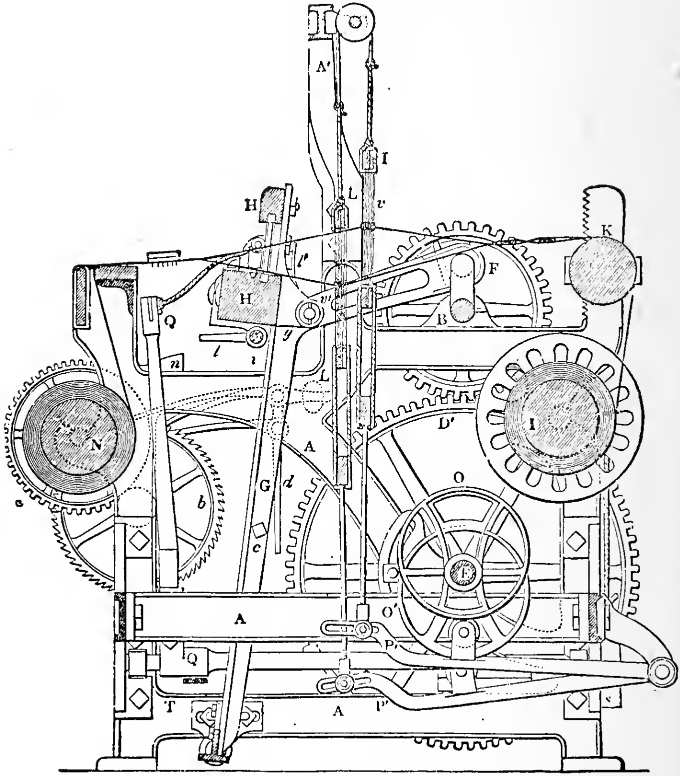

FIG. 89. — ROBERTS' LOOM, SIDE ELEVATION, 1830

The warp passes from warp beam (*I*), over roller (*K*), through heddles (*L*), through reed of batten (*H*); here the cloth continues over breast beam and is rolled upon cloth beam (*N*).

Wefting.

Shedding, Picking, Battening.

These processes proceed as in the Drop-box-shuttle hand loom, but automatically and in unison, with an additional automatic beam motion, and stop weaving motion.

*Economic Gain*

In production:

Introduction of steam power.

Automatic and continuous shedding, picking, battening and " letting-off " and " taking-on " motions.

In product:

Uniformly even and perfect web.

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Watson, J. F. "Textile manufactures and costumes of people of India." 1866.

Watson, K. "Textiles and clothing." 1907, 1916.

Weeden, W. B. "The art of weaving." Rept. Am. Historical Association. 1902.

Wilkinson, F. "Story of the cotton plant." 1899.

Wilkinson, J. G. "Ancient Egyptians." 1837, 1879. (Illustration.)

Willoughby, C. C. "New type of ceremonial blanket." Am. Anthropologist, XII, No. 1.

Woolman and McGowan. "Textiles." 1913.

Worcester, D. C. "Non-Christian tribes of northern Luzon." Philippine Journal of Science, I. 1906.

Zipser, J. "Raw textile materials." 1901.

# APPENDIX B

## MAGAZINE ILLUSTRATIONS

Compiled with the assistance of Anna la Tourette Blauvelt.

NOTE. — 1 = best examples. F = famous paintings.

*Spinning I*

| | | |
|---|---|---|
| | National Geographical Magazine. | |
| 1 | v. 23, Sept. 1912, p. 914. | Young Bontoc Igorot girl spinning. |

*Spinning III*

| | | |
|---|---|---|
| | National Geographical Magazine. | |
| | v. 15, Aug. 1904, p. 345. | Indian woman spinning, S. W. Mexico. |
| | p. 345. | Indian woman spinning, Mound builders. |
| | 16, Apr. 1905, p. 163. | Girl spinning, Tinguianes, Philippines. |
| | 19, Sept. 1908, p. 601. | Woman of Tiahuanoco, Peru. |
| 1 | 22, Sept. 1911, p. 804. | Native spinner of Tunis. |
| 1 | 25, June 1914, p. 628. | Lacondone women spinning cotton. |
| | Everybody's Magazine. | |
| | v. 6, Jan. 1902, p. 38. | Navaho woman spinning. |
| | Records of the Past, | |
| | slide and print, No. 4500. | Indian woman spinning and weaving. |

*Spinning IV*

| | | |
|---|---|---|
| F | Angelo, Michael. | The Three Fates.<br>orig. Pitti Palace, Florence.<br>repro. 375 Brown's Famous Pictures. |
| F | Millet, Jean François. | The Spinner.<br>562 Cosmos Picture Co.<br>562 University Prints.<br>Girl Spinning.<br>1362 Brown's.<br>505 Perry Pictures. |
| | Records of the Past.<br>slide and print, No. 379. | Gypsy spinning as she goes along the road, Asia Minor. |
| | National Geographical Magazine. | |
| | v. 17, Mar. 1906, p. 145. | Slave spinning. |
| I | 19, Nov. 1908, p. 768. | Bulgarian woman spinning as she walks to town. |
| | 20, Aug. 1909, p. 780. | Cretan woman spinning. |
| I | 25, Mar. 1914, p. 299. | A spinning woman, Holy Land (colored). |
| | 25, Mar. 1914, p. 313. | Man spinning in Jerusalem (colored). |
| I | 28, Oct. 1915, p. 370. | Roumanian woman with spindle. |
| | 28, Nov. 1915, p. 473. | Distaff spinner of Gourdin, France. |
| | 30, Nov. 1916, p. 107. | Domestic scene, Sardinia, So. Europe. |
| | 30, Sept. 1916, p. 198. | Roumanian girls making thread. |
| | 31, June 1917, p. 563. | The Hungarian gypsy mother. |
| F | Simmons, Edward. | The Three Fates.<br>New York Criminal Court House.<br>Copley Prints. |

| | | |
|---|---|---|
| | Underwood and Underwood. | |
| | Stereograph and slide, Negative, No. 6178. | Home duties of the Hopi Indians, Ariz. |
| F | Unknown Artist, Dutch, XVII Cent. | Old Woman holding distaff. Soule Art Co. |

*Spinning V*

| | | |
|---|---|---|
| F | Breton, Mme. Demont. | The Divine Apprentice.<br>Salon, 1897.<br>L'Illustration, Apr. 1879.<br>1669, Brown's. |
| | Country Life. | |
| | July 1903, p. 199. | Product of Kentucky mountain spinner. |
| 1 | Dec. 1905, p. 864. | Irish peasant spinnet. |
| | Craftsman. | |
| | Jan. 1902, p. 47. | Girl spinning on wool wheel, Kentucky. |
| | Harper's Magazine. | |
| | May 1910, p. 894. | An Aran woman and her wheel. |
| | International Studio | |
| | v. 58, Apr. 1916, p. LVII. | Types of spinning wheels. |
| | Illustrated London News Supplement. | |
| | Oct. 20, 1855, p. 474. | Spinning. |
| | Keystone View Co. | |
| | Stereograph, No. 14752. | Native silk spinning plant, Japan. |
| | 13496. | Carding and spinning wool, Telemarken. |
| | 13497. | Spinning in Telemarken. |
| F | Liebermann, Max. | Flax spinning in Laren.<br>National Gallery, Berlin.<br>Century Mag. frontispiece, July 1905. |

| | |
|---|---|
| McIntosh Stereopticon Co. | |
| Slide No. E 1047.9. | Tibetan man spinning wool. |
| Modern Mexico. | |
| July 1904, p. 21. | Mexican spinner. |
| National Geographical Magazine. | |
| v. 16, Apr. 1905, p. 182. | Ilocanos spinning cotton, Philippines. |
| 17, Mar. 1906, p. 145. | Moorish woman at spinning wheel. |
| 20, Feb. 1909, p. 190. | Spinner of Asia Minor. |
| 22, Aug. 1911, p. 711. | Dyak girl spinning, Borneo. |
| Records of the Past. | |
| slide and print, No. 11027. | Silk spinning. |
| Scientific American Supplement. | |
| v. 40, Oct. 1895, sup. no. 1033 | Fig. 5. Spinning the tussah. |
| 53, June 1902, sup. no. 1382 | Fig. 8. Spinning istle by hand. |
| F Velasquez, Diego Rodriguez. | Tapestry weavers (las Hilanderas).<br>Mus. of Prado, Madrid.<br>664 Perry.<br>Rhine Prints (colored). |

*Spinning VI*

| | |
|---|---|
| F Brekelenkam, Quiryn. | Camp, the spinner.<br>Metropolitan Museum, N. Y.<br>Met. Mus. Photo. |
| F Barse, George R. | Priscilla spinning.<br>1444 Brown's. |
| Craftsman. | |
| v. 1, Jan. 1902, p. 25. | Flax wheel and loom from old cut. |
| p. 29. | Flax wheels. |
| F Davey, Randall. | The courtship (J. Alden and Priscilla).<br>1634 Brown's. |

| | |
|---|---|
| F Gay, Walter. | The spinners (les fileuses). |
| | Irish spinner. |
| | Hull House Mus. postals, Chicago. |
| Illustrated London News Supplement. | |
| Aug. 26, 1905, p. 305, Figs. 4, 5. | Spinning. |
| Dec. 2, 1871, p. 533. | A winter evening in the Tyrol. |
| International Studio. | |
| v. 58, Apr. 1916, p. LVIII. | Types of spinning wheels. |
| F Maes, Nicholaas. | The old spinner. |
| | Museum Amsterdam. |
| | 750 Brown's. |
| F Marr, Carl. | Gossip. |
| | Metropolitan Mus. N. Y. |
| | Copley. |
| | 103 Emery. |
| F McEwen, Walter. | Telling ghost stories. |
| | 112 Emery. |
| McIntosh Stereopticon Co. | |
| Slide No. E 1047.8. | French peasant spinner. |
| National Geographical Magazine. | |
| I v. 24, Aug. 1913, p. 933. | A Swiss wheel and distaff. |
| 26, Sept. 1914, p. 206. | A spinner of Britanny. |
| p. 292. | Spinning bee near Berlin. |
| I 28, Nov. 1915, p. 417. | Aged spinner of France. |
| F Rembrandt, van Ryn. | Old woman spinning. |
| | Albertina Gallery, Vienna. |
| | Harper's Black and White Prints. |
| F Romney, George. | At the spinning wheel (portrait of Lady Hamilton). |
| | Artistic photo. Co. |
| Underwood and Underwood. | |
| Stereograph and slide neg. no. 6572. | Spinning, Breton home. |

*Spinning IX*

| | | |
|---|---|---|
| | Scientific American Supplement. | |
| | v. 31, Jan. 1891, sup. no. 785. | Crompton's mule in Chadwick's Museum, Boston. |

*Weaving II*

| | | |
|---|---|---|
| | Art and Decoration. | |
| I | v. 1, Mar. 1911, p. 208. | Ancient and modern looms. |
| | The Studio. | |
| I | autumn 1910, fig. 345. | Weighted warp loom. |

*Weaving IV*

| | | |
|---|---|---|
| | Leslie's Weekly. | |
| | Aug. 18, 1904, p. 153. | Igorote, weaving blanket. |
| | July 28, 1904, p. 83. | Igorote, weaving cloth. |
| | Keystone View Co. | |
| | Stereograph, No. 10051. | Weaving hemp into cloth, native method, Philippines. |

*Weaving V*

| | | |
|---|---|---|
| F | Allen, Frances and Mary. | Navajo weaver. |
| F | Brush, George de Forest. | An Indian weaver. Harper's black and white, 1899. |
| | Country Life in America. | |
| | Feb. 1906, p. 413. | Warping. |
| | p. 414. | Weaving the rug. |
| | Everybody's Magazine. | |
| I | v. 6, Jan. 1902, p. 35. | Navajo woman weaving at hogan. |
| I | p. 39. | Warping. |
| I | p. 40. | The loom ready for work. |
| I | p. 41. | The loom with design. |
| | McIntosh Stereopticon Co. | |
| | Slide No. E 1047.14. | Weaving Navajo blanket. |

| | | |
|---|---|---|
| | National Geographical Magazine. | |
| | v. 15, Aug. 1904, p. 346. | Indian weaver, S. W. Mexico. |
| | 19, Oct. 1908, p. 688. | Poncho weaver of Cuzco, Peru. |
| 1 | 23, Sept. 1912, p. 889. | An Ifugao woman making cloth. |
| | 23, Dec. 1912, p. 1280. | Bedouin women weaving woolen cloth. |
| | 29, May 1916, p. 454. | Making blankets on hand looms, Peru. |
| | 30, July 1916, p. 21. | Weaving a blanket in Indian Mexico. |
| | Underwood and Underwood. | |
| | Stereograph and slide neg. No. 6188. | Blanket weaving of Hopi Indians, Arizona. |
| | Records of the Past. | |
| | Slide and print, No. 4500. | Navajo woman spinning and weaving. |
| | 11826. | Navajo woman, Oraibe, Ariz. |
| | 4530. | Navajo woman completing rug. |
| | 4501. | Navajo blanket weaver. |
| | Scientific American Supplement. | |
| 1 | v. 10, Sept. 1880, sup. no. | Instruments used in weaving |
| 1 | 244, Pl. 1. | Aino cloth. |
| | Pl. 2. | Methods of stretching and tying threads. |
| 1 | Pl. 3. | Weaving Aino cloth. |
| | v. 53, June 1902, sup. no. 1382, Fig. 7. | Weaving istle bagging by hand. |

*Weaving VI*

| | |
|---|---|
| Illustrated London News Supplement. | |
| May 28, 1881, p. 525. | Native loom at Mangauya, E. C. Africa. |
| Penny Magazine. | |
| Aug. 24, 1883, p. 325. | Weaving in Ceylon. |

Scientific American Supplement.
I v. 51, May 1901, Figs. 1–10. Heddle frames.
I Fig. 11. Pueblo woman sitting on ground working heddle in weaving a belt.
I Fig. 12. Zuñi woman weaving ceremonial belt.

*Weaving VII*

Magazine of Art.
April 1900, p. 269. Chinese cotton cloth weaver.
National Geographical Magazine.
v. 19, Dec. 1908, p. 874. Woman of Korea weaving.
I p. 875. Woman unwinding thread for loom.
I p. 876. Starching thread and preparing it for loom, Korea.

*Weaving VIII*

Figaro Illustre.
Aug. 1900, p. 180. Weaving in Senegalais.
Illustrated London News Supplement.
May 17, 1879, p. 473. Weaving in Jellalabad.
Underwood and Underwood.
Stereograph and slide neg.
No. 3453. Shawl weavers at Cashmere.

*Weaving IX*

F Cooper, Emma L. The Weaver, Canada.
Phila. Water Color exhibit, June, 1906.
American Water Color Co. No. 449.
Country Life in America.
v. 4, July 1903, p. 198. Loom warped for weaving.
p. 199. Weaving.
10, June 1906, p. 863. A silk loom.
p. 254. Old hand loom.

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|---|---|
| Craftsman. | |
| v. 1, Jan. 1902, p. 28. | Hand looms, Halsemere, Eng. |
| p. 46. | Colonial loom, Kentucky. |
| I . 16, May 1909, p. 227. | Low warp loom, Herter tapestries. |
| 29, Nov. 1915, p. 224. | "Aunt Debby." Warps ready to be entered through heddles. |
| p. 224. | Blind Tom weaving rag rugs. |
| 29, Dec. 1915, p. 323. | Starting a coverlid with five heddles. |
| F Gay, Walter. | At the loom. 1030 Perry. |
| Illustrated London News Supplement. | |
| Feb. 6, 1875, p. 128. | Weaving Sarango, Java. |
| May 28, 1881, p. 521. | Matting weavers, Glasgow. |
| I Apr. 29, 1882, p. 413. | Royal tapestry looms at Windsor. Weaving, warping and repairing. |
| June 17, 1911, p. 945. | Weaving cloth-of-gold for the King and Queen. |
| International Studio. | |
| v. 58, Apr. 1916, p. LVIII. | Colonial hand loom. |
| Keystone View Co. | |
| Stereograph, No. 13499. | Weaving woolen blankets on primitive hand loom, Telemarken. |
| 14754. | Native loom, Kirju, Japan. |
| McIntosh Stereopticon Co. | |
| Slide, No. 1046.15. | Japanese looms. |
| E 1047.10. | Weaving at loom in Norway. |
| E 1047.19. | Weaving Gobelin tapestries, France. |
| E 1047.20. | Weaving Gobelin tapestries, France. |
| E 1078. 74. | Weaving Persian rugs. |

| | |
|---|---|
| Modern Mexico. | |
| June 1903, p. 27. | Weaving. |
| National Geographical Magazine. | |
| v. 16, Apr. 1905, p. 182. | Looms of the Ilocanos, Luzon. |
| 20, May 1909, p. 470. | A Swedish home. |
| 24, Nov. 1913, p. 1241. | Benguet Igorot girls weaving. |
| 1 28, Oct. 1915, p. 340. | Armenian rug weavers at Van. |
| Records of the Past. | |
| Slide and print, No. 11028. | Factory weaving in Japan. |
| Scientific American Supplement. | |
| v. 48, Aug. 1899, Sup. No. 1232. | The carpet workers, Gobelin. |
| Southern Workman. | |
| Apr. 1903, p. 211. | Hand loom. |
| June 1903, p. 278. | Weaving in Macedonia. |
| The Studio. | |
| Autumn 1910, fig. 345. | Crude loom Nn. Museum, Stockholm. |
| Underwood and Underwood. | |
| Stereograph and slide neg. No. 9574. | Weaving royal Gobelin, France. |
| 4639. | Weaving Pima cloth, Philippines. |
| 6419. | Natives weaving matting, Mexico. |
| 3886. | Peasant weaving cotton, Japan. |
| 11467. | Arab weaver, Syria. |
| 11468. | Weaving, Syria. |

*Weaving X*

| | |
|---|---|
| International Studio. | |
| v. 42, Nov. 1910, p. 40. | Ancient Japanese loom for weaving brocades from the Shokurin Burni by Minko. |

*Weaving XI*

McIntosh Stereopticon Co.

| | |
|---|---|
| Slide No. E 1049.14. | Jacquard for linen. |

Scientific American Supplement.

| | |
|---|---|
| v. 69, Apr. 1910, sup. no. 1790. | Building up the Jacquard harness. |
| 1790. | Jacquard figured goods. |

Underwood and Underwood.

Stereograph and slide neg.

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|---|---|
| No. 11446. | Warping mill — silk. |
| 11448. | Entering silk through heddles. |
| 14519. | Jacquard weaving. |

# APPENDIX C

## BOOKS FOR JUVENILES WITH ADDITIONAL ILLUSTRATIONS

Compiled by Anna la Tourette Blauvelt.

Adams, Cyrus W., Commercial geography. D. Appleton & Co. 1911.
Allen, Nellie B., Geographical and industrial reader. Ginn & Co. 1916.
Baker, Emile Kip, Stories of old Greece and Rome. Macmillan, 1913.
Baldwin, James, Old Greek stories. American Book Co. 1895.
Beard, L. and A. B., Recreation for girls. Chas. Scribner & Sons. 1914.
Bonawitz and Coleman, Little travellers around the world. A. S. Barnes & Co. 1907.
Bulfinch, Thos., Golden age of myth and legend. F. A. Stokes & Co.
Bulfinch, Thos., Mythology. T. F. Crowell Co. 1913.
Carpenter, Frank G., How the world is clothed. Amer. Book Co. 1908.
Chamberlain, James F., How we are clothed. Macmillan Co. 1904.
Champlain, J. D., Young folks cyclopedia of common things. Henry Holt Co. 1908.
Chase, and Clow, Stories in industry, II. Educational Pub. Co. 1909.
Colonial Stories retold from the St. Nicholas. Century Co.
Customs of the world. Paternoster Row, London.
Davis, John W., Evenings with Grandma. D. C. Heath. 1911.
Emory, Mabel S., How to enjoy pictures. Prang Co. 1898.

Gayley, Charles Mills. The classic myths in English literature and art. Ginn & Co. 1911.

Grover, Eulalie Osgood, Art literature readers, I. Atkinson, Mentzer Co. 1904.

Guerber, H. A., Myths in northern lands. Amer. Book Co. 1895.

Hancock, Mary S., The children of history. Little, Brown, & Co.

1 Harding, Samuel B., The story of England. Scott, Foresman & Co. 1909.

Hilton and Rollins, Industrial work for public schools. Rand & McNally. 1904.

1 Holbrook, Florence, Round the year in myth and song. Amer. Book Co. 1897.

1 Keller and Bishop, Commercial and industrial geography. Ginn & Co. 1916.

Kingsley, Charles, The heroes. E. P. Dutton & Co.

1 Kinne and Cooley, Clothing and health. Macmillan Co. 1916.

1 Kinne and Cooley, Shelter and clothing. Macmillan Co. 1913.

Lang, Jean, Book of myths. Putnam.

Morris, Charles, Home life in all lands. Lippincott Co. 1909.

Poulsson, Emily, In the child world. M. Bradley. 1898.

Richmond, Celia, England, Scotland and Ireland. Ginn & Co. 1914.

Rocheleau, W. F., Great American industries. A. Flanagan Co. 1906.

Shillig, Eleanor E., The four wonders. Rand & McNally. 1913.

Warner, Charles F., Home decoration. Doubleday Page & Co. 1911.

1 Williams, Archibald, How it is made. Thomas Nelson & Sons.

1 Wilmot-Buxton, Stories of Norse heroes. T. Y. Crowell Co. N. Y.

# INDEX

Printed in the United States of America.

# Textiles

## A Handbook for the Student and the Consumer

BY

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*Illustrated, Cloth, 12mo, xi+428 pp., Index, Bibliography, $2.00*

This book is the result of twenty years' experience in teaching textiles to college students. It is intended as a textbook for college classes or for study clubs and as a guide for the housekeeper or individual consumer of textiles and clothing, the teacher, the club woman, the saleswoman, and as an introductory survey of the subject for the student who contemplates professional work in the textile industries.

The growing emphasis upon textile study in college departments of home economics or household arts, and the increasing use of the textile industry as teaching material in other departments and other grades of schools, shows a recognition of the part that the textiles are playing in the development of civilization and in our everyday life. Interest in the subject is still further accentuated by the movements now on foot to regulate the social-economic conditions in the textile and clothing industries and to secure standardization and honest labeling of textile products, as is being done for food products by the "pure food laws."

To meet the existing need the authors have attempted to prepare a text suitable for use in college classes or by the public, shorter and more readable than the technical handbooks, yet sufficiently thorough and comprehensive to give a sound grasp of the subject as a whole with so much of the technology as is directly helpful to the consumer and as should be included in general courses in colleges and technical or vocational schools.

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